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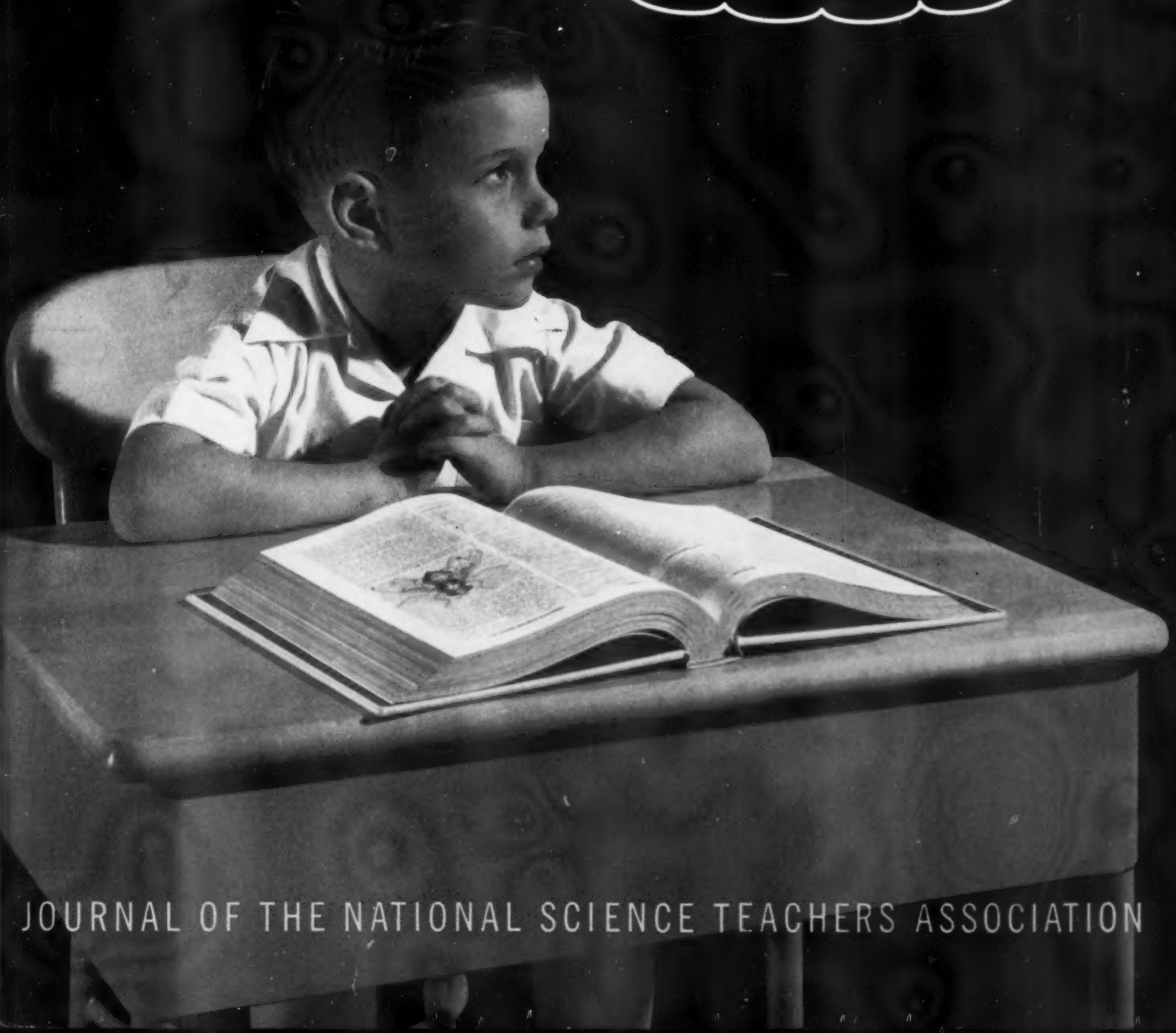
NOVEMBER 1959

THE SCIENCE TEACHER

WHAT IS EDUCATION?



JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

THE SCIENCE TEACHER

The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Volume 26, Number 7 **November 1959**

Editor's Column

If science is worth teaching at all, it's worth teaching well. The same should, of course, be said of algebra, music, bookkeeping, swimming, or anything else decided upon as worthy of inclusion in the curriculum. But it seems we still have a long way to go in developing understanding by school administrators, school boards, our colleagues, and the public of the fact that teaching science is more than just a shade different.

An assignment to teach a schedule of, say, two classes in biology, two in chemistry, and one in physics (by no means an exaggerated example) is a formidable task: three different preparations, three different programs of laboratory work and demonstrations with apparatus and supplies to prepare, use, clean, repair, and store. This, together with the usual preparation for class periods and the normal amount of marking of papers to be done, adds up to far more than teaching five classes in any combination of algebra, geometry, and trigonometry, or civics, world history, and U. S. history.

One of our mistakes has been to label all of the courses we teach "science." This tends to equate biology to physics to ninth-grade general science, etc. Actually, biology and physics, for example, are separate disciplines by a far wider divergence than algebra and trigonometry or civics and world history. This imposes a tremendous burden on the conscientious teacher who accepts the thesis that laboratory work designed to foster self-discovery, critical thinking, and problem solving is the necessary, basic element in good science teaching. As one overloaded NSTA member recently wrote, "The school administrator must be shown that a fair and equitable teaching load does *not* consist in the same number of teaching hours, but that the nature of the subjects taught and the preparation required for effective teaching *must* be considered."

Below are some suggested standards I deem to be reasonable, based on my experiences and observations through twenty years of classroom teaching. Given a six-period day with single, 50-60 minute periods daily:

1. One full-time laboratory assistant for each two or three regular classroom teachers; or

2. No more than five classes or two different preparations daily for any teacher and one completely "free" period every day; or

3. No more than four classes or assignments and two "free" periods daily for teachers with three or more fields in which to make preparations.

Perhaps these points will be contested, but I believe a careful job analysis would support these views. In any event, the question is open for discussion. Chop away.

Robert H. Carleton

THE SCIENCE TEACHER

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* Includes the *Elementary School Science Bulletin*.

Readers' Column

SEPTEMBER ANNIVERSARY ISSUE

A word of thanks to the members and advertisers for the many letters commending our special anniversary effort. It could not have come to successful fruition without the cooperation of those of you who participated. Responses from new members on their first look at our publication began coming in the second week after mailing, and are still pouring in.

May I express my thanks, through you, to the members of the Board of Directors for the nice recognition, in the form of a medallion, for my modest participation in the work of our Association. May I also comment briefly on major successes of the Association and on its major potentialities.

Under the leadership and the direction of its Board of Directors and employed officers, the growth of the Association and its influence on public education has been phenomenal. This statement is supported by the observation that in the interval of a few years it has gained a large membership with increased attendance at its meetings and with greater participation from the membership in its programs. It has indeed become a powerful forum for advancing the education of children and of their teachers in science, and for the improvement of facilities for advancing science education.

A notable feature of this growth in magnitude and in influence is in the further observation that the Association has achieved much success in bringing representatives of all science teaching interests to the same conference rooms. An indication of the significance of this achievement is in the extent to which these members with many diverse interests are deriving personal and professional satisfactions from the meeting of minds that come as they discover and discuss their common interests in science and science education. This discovery of common interests, which has occurred in conference rooms sponsored by this Association, has led to increasing concern and to organized efforts to gain for science its proper recognition in the total scheme of education, and in turn to gain for science its proper recognition in the total culture.

The strength of NSTA is not primarily in its contribution to the advancement of scientific research, but instead in its contribution to advancing education in science among the masses of the people. It may be said, as a corollary, that the achievement of this primary function of advancing widespread understanding of science will surely be accompanied by reasonable consideration on the part of a larger proportion of the total population of the need for scientific specialists and of the means to be employed in enlisting them.

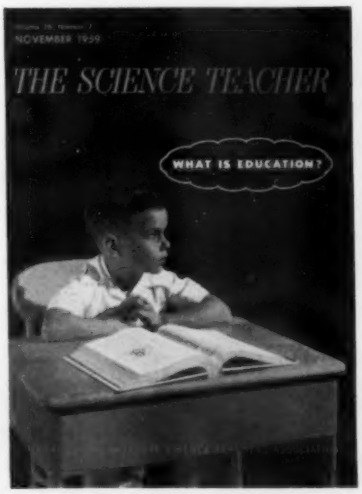
The potential of NSTA is in the opportunity it offers to competent teachers to have a part in advancing general education in science.

S. Ralph Powers
90 Adams Avenue
Haworth, New Jersey

I would like to take this opportunity to express my gratitude to the American Society for Metals and the Future Scientists of America Foundation for sponsoring the Student Achievement Awards Program and for making these awards available. I feel that this is the top program of its kind for getting students to do actual research on the secondary school level. Not only does it stimulate basic scientific research, but the student must also be able to adequately express himself in presenting his work in the form of a paper for this contest.

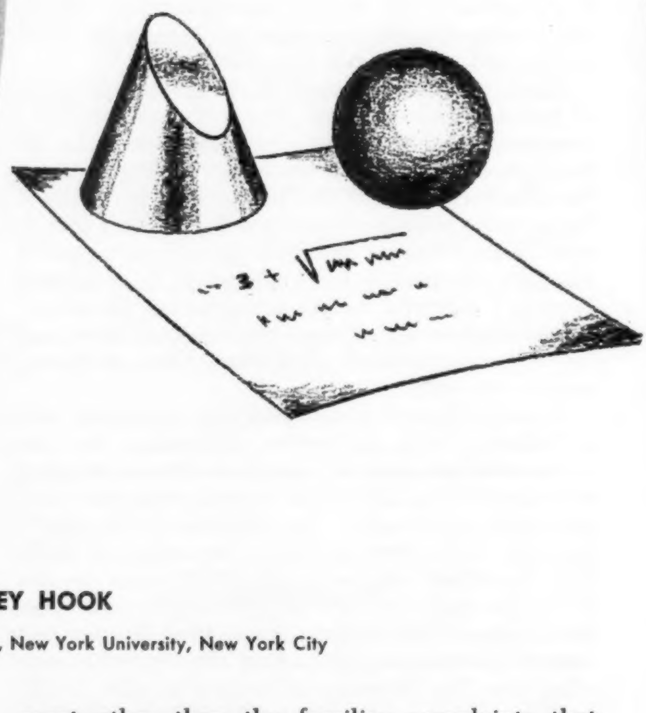
Bill E. Ash
Tyner Junior High School
Tyner, Tennessee

THIS MONTH'S COVER . . .



As your attention is directed to the pensiveness of the pupil on the cover, you too are urged to reflect and examine the critical question posed. A lucid and intellectually stimulating analysis of the subject is presented in the lead article of this issue (page 462).

What Is EDUCA



By SIDNEY HOOK

Chairman, Department of Philosophy, New York University, New York City

FEAR and panic, resulting from recent technological and military advances in the Soviet Union's power, have produced outcries against our schools and spawned proposals to reorganize the whole of American education. But it is hard to find among these criticisms any items of agreement other than the familiar complaints that American education has become soft and intellectually contemptible; that professors of education are responsible for our deplorable condition (not the much larger number of professors of other subjects who until recently hardly recognized their role as educators); and that John Dewey is the evil genius who misled them. The writings of Dewey themselves remain largely un-

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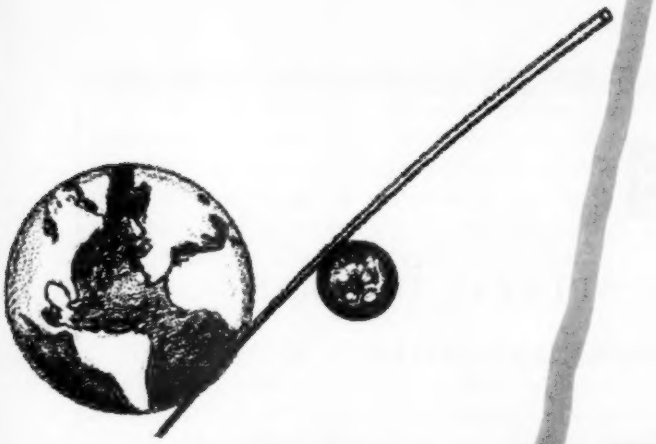
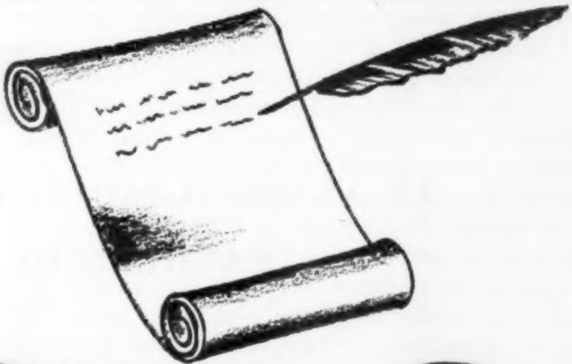
NOTE: Condensed and reprinted, with appreciation, from *Education in the Age of Science* (see Book Reviews, p. 523) by permission of the author and the publisher.





CATION?

read and misread. Simple justice requires us to recognize that it was Dewey rather than any of his multitudinous critics who foresaw the general nature of our crisis. It was Dewey who called upon educators first to take note of the vast effects of the scientific revolution upon our society and its educational needs, and later to recognize the Communist threat to the free world.

In this essay I shall restate and defend what I believe the ends of American education should be for our time and our place in history. For purposes of convenience I divide the ends of education into three overlapping groups: (a) powers and skills, (b) knowledge of subject matter or fields of study, and (c) moral habits, values, and loyalties.

Powers and Skills

Education should aim to develop students' capacities to write and speak clearly and effectively, to deal competently with number and figure, to think critically and constructively, to judge discriminatingly and observe carefully, to appreciate and respect personal and cultural differences, to enjoy with trained sensibility the worlds of art and music, and to enrich the imagination and deepen insight into the hearts of men by the study of literature, drama, and poetry.

Why? Three generic reasons are sufficient. We must all communicate with each other, no matter what our business and vocation, in a world of increasing specialization. The effective exercise of these powers enables us to make our experiences more significant and to share them, if we so desire, more readily with others. The ability to think increases the power to solve problems and increases our satisfaction; it multiplies alternatives of choice and makes us freer men. The development of our capacities of aesthetic appreciation and imaginative identification multiplies the occasions for joy and delight in a tragic world. The values in the light of which these consequences are appraised are not themselves beyond question and dispute. More controversial is the question whether the powers and skills we seek to develop in education should also include those necessary to earn a living. The question here is whether the schools should take the responsibility of helping students in their choice of and preparation for a calling, or whether industry should do it on the job; if the schools should assume this task, whether they should do it in special vocational institutions or in those of gen-

eral or liberal studies; and if in the latter, at what point in schooling and with what relationship to nonvocational studies. The answers depend not so much upon first philosophical principles as upon the character of the society in which our students will live and upon our conception of what constitutes a democratic education.

Fields of Study

With respect to subject matters and fields of interest, all students should acquire an adequate knowledge of the physical and biological world—of the forces that play upon and govern man's habitat, limit his place in nature, and determine the structure and behavior of his body and mind.

Why? Such knowledge is necessary to make the student's everyday experience intelligible to him. He will be more at home in the world. He will have a better understanding of scientific method in action—especially if he is properly taught. He will become more acutely aware of the revolutionary impact of science and technology on human culture. If he rises above the level of the earthworm and wonders about human origins and destinies, this knowledge will help him to develop a reflective view of the place of man in the universe, of God's existence, of the meanings and evidences, if any, of immortality and human freedom.

A second field of interest and subject matter is history and the social studies. There is a universal need for all individuals to understand the society in which they live. Every student is a future citizen who cannot make intelligent choices in political affairs, or even in some of his personal affairs, without learning something of the massive economic and social forces that mold contemporary civilization. Educators disagree not about the desirability of instruction in these subject matters but only on the relative emphasis to be placed on the distant past, the recent past, and the contemporary. It seems to me that the key to wise selection of materials from the past is relevance to the great issues, problems, and challenges of our age that must be mastered if we are to survive as a free culture.

The fact that some selection must be made indicates that here and elsewhere we must be guided by some notion of importance, relevance, or strategic perspective. Not everything is relevant to everything; although all subject matters and all experiences have some worth to someone, they do not all have the same quality or the same worth in the educational enterprise which seeks to make the individual feel at home in a world of change.

What John Dewey says of experience seems to me also to be true of the subject matters experienced—stamp-collecting is not as good as geography and history if we want to understand the map of the world today; the study of Greek and Latin words in English use is not equivalent to the study of good English usage for purposes of better writing and speaking. As Dewey observed in *Experience and Education:*

> The belief that all genuine education comes about through experience does not mean that all experiences are genuinely or equally educational. Experience and education cannot be

MADISON PUBLIC SCHOOLS, WISCONSIN

Acquiring value judgments through study of other cultures and philosophies.

Early studies should include history and the social studies, in addition to science.

DENVER PUBLIC SCHOOLS, COLORADO

directly equated to each other. For some experiences are miseducative. Any experience is miseducative that has the effect of arresting or distorting the growth of further experience. An experience may be such as to engender callousness; it may produce lack of sensitivity and responsiveness. Then the possibilities of having richer experience in the future are restricted.

A third field of study that should be required of all students, particularly in the colleges, is a study of the great maps of life. The value judgments and commitments of the major philosophies and religions that have swayed multitudes, as well as the visions of solitary figures of deeper thought but lesser influence, bear directly upon some of the ideological conflicts of our age. No wise policy can be formulated independently of the facts, but no mere recital of the facts determines policy. In the end, a decision between conflicting social philosophies involves a choice among key moral values. Sometimes this is true in what appears to be merely questions of limited means. For example, hard decisions about nuclear defense in the grim days ahead of us involve commitment to ideals on which we may literally have to stake our lives. Surely this is justification enough to make a critical and searching study of the grounds, alternatives, and consequences of the great ideals for which men have lived and died.

Values and Loyalties

This last reference is a proper transition point to the aims of education that bear upon moral habits, fundamental loyalties, and what is called character education. I do not believe that the intellectual and moral virtues—whether a love of the truth, a sense of chivalry and fair play, a feeling of outrage before cruelty, sympathy for the underdog, or a passion for freedom—can be instilled by didactic instruction. They can be imparted, if at all, only by indirection, by skilled teaching on the part of teachers who care, and only when students learn well the other things encompassed by the aims. How, for example, do we go about developing intellectual and emotional maturity in students? Not by preaching but by setting them tasks of progressive complexity. If the sign of maturity is the possession of habits of reasonable expectation, I do not know how this can be built up except by getting students to learn from lesson to lesson what the world is and what it might be, and relating the possible ideal fulfillments to the limiting conditions that govern men and things. Immaturity may be as much present when we settle for too

little, blind to what may be, as when we demand too much, blind to what cannot be.

It is our faith in the educational process as a whole that sustains us in our belief that those who complete their schooling will have acquired loyalties to the enduring values of the human community.

John Dewey has placed great emphasis upon this aspect of the continuity between past and present. In *A Common Faith* he writes:

> The things in civilization we most prize are not of ourselves. They exist by grace of the doings and sufferings of the continuous human community in which we are a link. Ours is the responsibility of conserving, transmitting, rectifying, and expanding the heritage of values we have received that those who come after us may receive it more solid and secure, more widely accessible, and more generously shared than we have received it.

The nature of education is such that even when learning is a process of discovery the greatest weight must fall upon the knowledge and wisdom of the past. It could not be otherwise. It takes time for the individual to discover that there are many pasts or many interpretations of the past, and that anything that is genuine knowledge must prove itself in the present, and therefore need not fear challenge. It takes more than time. It takes intellectual courage, the rarest of all intellectual virtues. Those who make a fetish of the past, of historical continuity, of piety before the traditional, live off the intellectual capital of their ancestors' courage. The gabble in the academies about the vice of conformism and the virtue of nonconformism is empty and meaningless. Hitler was the greatest nonconformist of the twentieth century. What we must cherish is not conformity or nonconformity, agreement or disagreement but intellectual independence, the courage to hold a position, on the strength of evidence, no matter what the baying of the crowd.

Once we accept these objectives as the ends of education, or any equivalent set, I believe we can easily show that many of the antitheses that plague current discussions of the subject may be resolved. I wish to consider briefly two of them.

The Intellect Versus the Whole Man

The first is the dispute over whether the end of education should be education of the intellect or of the whole person. Both positions seem to me untenable. The intellect or mind is not an abstract, disembodied power. It influences and is

(Continued on page 516)

STUDY OF ATTITUDES

By HUGH ALLEN, JR.

Associate Professor of Physics, Montclair State College, Upper Montclair, New Jersey

EDITOR'S NOTE: The attached report is an abstract of a Science Manpower Project Monograph prepared by Dr. Allen for publication by the Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y.*

MODERN industrial societies require highly trained scientific and technical personnel. There never seems to be enough of such trained personnel to meet demands, even in periods of moderate economic activity. For the United States, the problem is not only one of quantity, but also of quality. This problem presents to the American people a great challenge to engage in systematic, long-range planning for the best use of human resources within the framework of a democratic society, where everyone is free to make his own career choice. It was the recognition of the "free career choice" aspect of the manpower problem which motivated this study of the attitudes of young people toward science and scientific and science-related careers.

Basic to this problem is the question as to why more of our high-ability young people are not presently choosing scientific or engineering careers. Comparing the highest intelligence groups (those in the top eighth of their high school graduating classes) of this 10 per cent sample of New Jersey public high school seniors, it was ascertained that those choosing professional scientific careers differed in their attitudes on 29 items of a 95-item scale, at an acceptable confidence level. Opinions on these items seem to differentiate between those choosing scientific careers, and those choosing other careers and possessing the high intellectual ability generally agreed to be required for creative scientific work. While the attitudes of both groups were considered to be positive and constructive (as compared to the responses expected by a select group of judges), opinions on these 29 items may well indicate deterrents to scientific career choice. These statements listed in rank order were:

91. Scientists are usually unsociable.
29. Scientists are shy, lonely individuals.
31. For me, training for a career in science is not worth the time and effort required.
42. Scientific work is boring.
46. I don't have the intelligence for a successful scientific career.
26. It is undemocratic to favor exceptional scientific talent.
3. Scientists are seldom concerned with their working conditions.
54. Scientists are "eggheads."
73. Scientists are against formal religion.
86. Scientific work is monotonous.
90. Scientists are often willing to sacrifice the welfare of others to further their own interests.
69. Universities do little scientific research that is of immediate practical value.
5. Friends often discourage girls from taking high school science courses.

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*Entitled *Attitudes of Certain High School Seniors Toward Science and Scientific Careers* (1959, 54p.), it is available at $1.25 per copy from Teachers College, Columbia University.

83. American scientists are largely responsible for our country's status among nations.
65. The engineer serves a more practical purpose in society than does the research scientist.
87. The working scientist believes that nature is orderly rather than disorderly.
37. Scientists are an "odd" lot.
80. Public interest in science is essential to the maintenance of scientific research.
8. Scientists are too narrow in their views.
55. Scientific work requires long years of labor and self-discipline.
19. Scientists are willing to change their ideas and beliefs when confronted by new evidence.
68. The average American home discourages girls from scientific careers.
82. Many specific findings in science contradict the laws of God.
23. Modern science is too complicated for the average citizen to understand and appreciate.
14. A scientist might aptly be described as a nonconformist.
13. The scientist will make his maximum contribution to society when he has freedom to work on the problems which interest him.
7. Increased radiation resulting from bomb tests is a threat to civilization.
28. Hazards created by the increased use of radioactive materials make scientific work less attractive than previously.
22. The complexity of science hides its cultural values.

In general, do high school seniors have positive, constructive attitudes towards science and scientific endeavor? The correlation between the scale score of the judges and the percentage agreement for the total sample of 3057 was .770. On disagreement this correlation was .808. One may justifiably conclude from these correlations that high school seniors, taken as a group, *do* have positive and constructive attitudes towards science. It should be noted, however, that an item analysis makes clear that on many important matters related to a public image of science and scientists there was misunderstanding, confusion, and possibly ignorance exhibited by substantial numbers of the seniors responding to the statements on the attitude inventory.

Do high school seniors choosing scientific careers have more positive, constructive attitudes towards science and scientific endeavor than those choosing other careers? The correlations between the science and non-science groups, the judges and the science group, and the judges and the non-science group were so high in each case as to indicate no significant differences between any of these groups. Differences did occur, of course, on specific items—mainly those relative to a knowledge of scientific work.

Is the intelligence of the high school senior related to his attitudes regarding science and scientific endeavor? For over one-half of the item responses on the attitude scale employed, there were substantial differences when analyses were made by intelligence quarters. Thirty-eight items were identified which showed a consistent increase or decrease in percentage of agreement or disagreement from the first to fourth quarters. This difference was significant for 37 of these items, requiring a provisional affirmative answer to the question. For the total sample, 17 (46%) of these 37 statements referred to the scientist and his work, 7 (19%) to the nature of science, 11 (30%) to the interaction of science and society, and 2 (5%) to the student's evaluation of his personal interest and ability in relation to a scientific career.

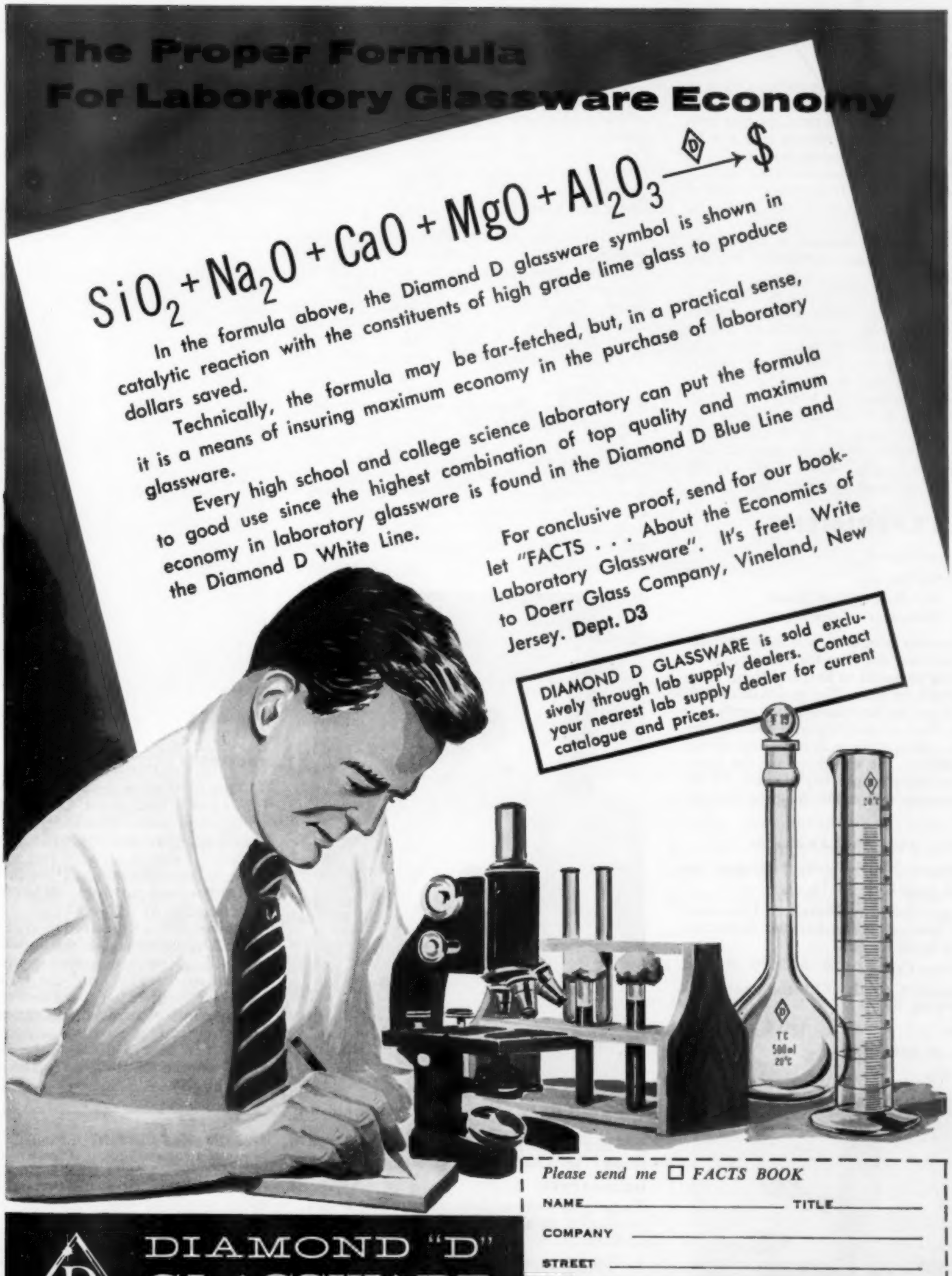
For the group who indicated a career choice in science or engineering, a significant difference was indicated (at the 1% level of confidence) for 21 items. The five statements of importance, in rank order, were:

3. Scientists are seldom concerned with their working conditions.
82. Many specific findings in science contradict the laws of God.
45. Scientists display an almost irrational attachment to their work.
15. Scientists should be looked upon as "subjects for suspicion."
90. Scientists are often willing to sacrifice the welfare of others to further their own interests.

For the non-science career group, a significant difference (at the 1% level) was found on 30 items when the first and fourth intelligence quarters were compared. In rank order, the five statements of most importance were:

95. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.
15. Scientists should be looked upon as "subjects for suspicion."
62. The neglect of basic scientific research would be the equivalent of "killing the goose that laid the golden eggs."
84. Scientists are essentially magicians, making two blades of grass where one grew before.
48. Scientific findings always lead to final truths.

The author invites comments from readers who may be interested in examining the findings in the completed monograph.



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AO Reports on Teaching with the Microscope

A Short Course on Carassius auratus Hematal or who slipped Fin the Mickey

One of the most fascinating sights a student can observe in a biology course is the complex network of the blood circulatory system in action. Although the system may not be viewed in its entirety, the student is able to see a large enough portion, with the help of a microscope, to identify arteries, veins and capillaries...visually establish the particular function of each.

Subject for the experiment is a goldfish, picked for reasons which our author, Mr. Ted Stopyra, explains below. Observation medium for the experiment is the AO Spencer No. 66 Student Microscope which we have picked for what might at first seem selfish reasons... but realistically not so, when you consider that this is an instrument ideally suited for student microscopists.

With construction that's foolproof and rugged, the No. 66 Student Microscope defies wear. Incorporating the finest optical elements, you have an instrument that will provide precise, long term service even under constant use by the most active class.

EXPERIMENT

Circulation of Blood

By: Ted Stopyra
Middletown High School
Middletown, Connecticut

To demonstrate blood in action a goldfish was selected over the frog for many reasons. Frogs pose a problem in keeping them alive for any length of time. The goldfish on the other hand can be kept alive indefinitely.

The problem of keeping and feeding the goldfish is a minor chore as compared to the frog. In addition, the anesthetizing, the maneuverability and transparency of the fish's fin far surpasses the web of the frog for this experiment.

MATERIALS AND PREPARATION

1. AO Spencer No. 66 Student Microscope
2. Lantern glass slide 3½" x 4¼"
3. Living goldfish (the Fantail or Common Comet species). Preferably two inches or more in body length.
4. Absorbent Cotton
5. Chloretone Crystals (Chlorobutanol-hydrous) 1 oz.
6. Pipette
7. Beaker of water
8. Cover slip

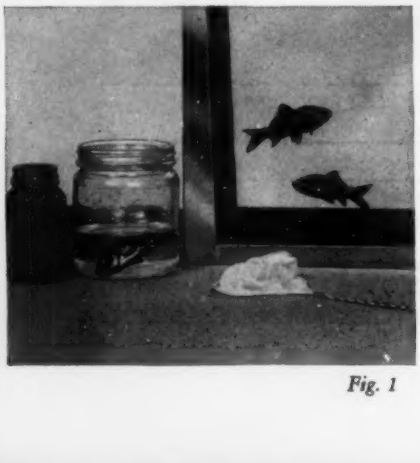

Fig. 1

Chloretone is mixed by adding one ounce of Chloretone crystals to eight ounces or 236 c. c. of water in an amber glass bottle. Shake the contents and let the solution stand. The chloretone solution keeps well even though the crystals are slightly soluble.

PROCEDURE:

1. To anesthetize the goldfish you place four ounces, or 118 c. c., of water in a beaker or wide rim container such as a mason jar. Then add one or two teaspoons of Chloretone solution to the water, stir and place goldfish into solution. In a few minutes the goldfish slows down and rolls over on its side. (Fig. 1) The fish will remain anesthetized for an hour or two.

2. When the fish obtains the side position, remove the fish from the Chloretone solution and wrap a layer of dripping wet absorbent cotton around its body and place on a lantern slide. It is best to saturate the cotton with water from the tank or container the goldfish came from originally. When covering the body with cotton, place it in such a way that the mouth is not covered and the posterior tail is exposed.

Fig. 2

3. Place the prepared slide under the microscope (Fig. 2) and focus under low power.

OBJECTIVE:

To provide a visual demonstration of blood circulation in a living animal containing a backbone.

1. Once the specimen is focused, one readily notices the movement of blood through the blood vessels. Arteries are identified by the flow of blood toward the fin. Veins on the other hand are recognized by the flow of blood toward the head. Connecting these vessels are hair-like structures called capillaries. Blood cells flow through these capillaries one at a time.

2. By changing the objective to 43x and adding a cover slip, the lymph vessels and capillaries become very clear. Lymph vessels are recognized by the slow rate of movement of corpuscles through them in comparison to the blood vessels.

3. To observe coagulation one just has to pierce the fin with a pin and thereby rupturing many capillaries.

Fig. 3

RECOVERY:

1. One method of reviving the fish is to put it in a pail of fresh water. Ordinarily it would swim off at once. However, this does not always happen. The preferred method is to subject the fish to artificial respiration. This is administered by holding the fish between two fingers and pushing it through the water rapidly. (Fig. 3)

Seldom does a fish fail to revive because the water is forced through the mouth and out the gills. A rapid motion introduces more oxygen to the gills, and the more oxygen absorbed the speedier the recovery.

The length of artificial respiration depends upon how long the fish was under the microscope. It is best to continue the use of artificial respiration until the fish swims out of one's fingers.

College Preparation of Science Teachers

Kansas High School Teachers of Science Recommendations

By JOSEPH D. NOVAK and MERLE E. BROOKS

Kansas State Teachers College, Emporia

IN recent years, a number of reports have been published which directly or indirectly specify the college preparation needed to teach science in the high school (1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14). These reports have been prepared by college professors and outstanding high school science teachers. We feel that the recommendations made in these reports are desirable, but our experiences with teachers and administrators in Kansas high schools have suggested that some of the recommendations may not be practicable.

It was our hope that some information could be obtained as to what high school teachers of science consider necessary preparation to teach high school science subjects. We have recognized a lack of awareness on the part of many "science teachers" as to what preparation is necessary.

Many teachers whom we have visited in high schools in past years had difficulty as science teachers because they were not adequately prepared in the subjects they were teaching. Unfortunately, some of these teachers did not consider themselves inadequate in their academic preparation. Incidentally, we have noted also that many science teachers are ineffective primarily because of their lack of understanding of how young people learn and, consequently, how to teach children.

Method and Scope of the Study

We feel that the data in this report have significance in three respects. First, Kansas high school science teachers are, as a group, very modest in their recommendations for college preparation in science. Second, even these modest recommendations exceed the certification requirements for science teachers of Kansas and some other states. Third, and perhaps most important, the attitude expressed by the teachers, as evidenced in the responses, suggests that too many science teachers are satisfied with little or no basic college course work in science subjects taught in the high school.

NOTE: Present address of author Joseph D. Novak is Purdue University, Lafayette, Indiana.

A three-page questionnaire was developed which contained a listing of college courses that commonly appear on transcripts of teachers of general science, chemistry, physics, or biology. Under each of the subject areas, a list of courses was given and the teachers were asked to indicate whether they felt that the course was *essential, helpful,* or of *little value.* They were also asked to place an asterisk after those college courses which they regarded as an *absolute minimum* needed to teach the particular science subject in high school.

The questionnaires were mailed to 253 science teachers selected at random from a list of science teachers of Kansas (5). Ten days after the questionnaires were sent, about half had been returned, after which the returns dropped to one or two per day. A follow-up letter, with a copy of the questionnaire, was sent to the teachers who had not responded.

All questionnaires returned three or more days after the follow-up letter was sent were tallied separately. No noticeable differences were found in the response patterns of the late respondents when compared with the responses of the first respondents. It was concluded that the questionnaire responses from the two groups could be treated as a sample from one population. In all, 196 or 77.4 per cent were returned.

Results and Interpretation

The number of teachers who indicated a course "essential," "helpful," or "little value" was recorded for each college science course listed. The total number of responses for the three categories did not equal the total number of returns, since some of the teachers did not rank courses under chemistry or other high school sciences if they were not teaching these courses or did not feel competent to judge the value of specific college preparation for that subject. Using the number of teachers responding in the three categories, "essential," "helpful," "little value," for each college course, the per cent of total responses was recorded for each of the three categories. A separate tally was made of the college science courses listed as an "absolute minimum" needed to teach the high school science. The number of respondents who indicated a particular college science course as an "absolute minimum" was divided by the total number of respondents for that course to obtain the per cent of teachers who regarded the course as "absolute minimum." The data are summarized in Table I.

Of the 196 teachers who returned the questionnaires, 181 rated the value of Physics I for the teaching of high school general science. Ninety per cent of the respondents indicated that Physics I was "essential" and 65 per cent of the respondents indicated that it was part of an "absolute minimum" preparation needed to teach general science. College General Biology was regarded as "essential" by 86 per cent of the respondents and College Chemistry I by 85 per cent. General Biology and Chemistry I were marked "absolute minimum" by 62 per cent and 60 per cent respectively. All other courses listed were marked as "essential" by fewer than 43 per cent of the respondents and as "absolute minimum" by fewer than 19 per cent. Both General Geology and Astronomy received relatively high ratings.

For high school chemistry, 100 per cent of the 159 respondents indicated that Chemistry I was "essential" and 80 per cent marked the course as an "absolute minimum" needed. Ninety per cent of the teachers indicated that Chemistry II was "essential" and 68 per cent of these respondents regarded the course part of an "absolute minimum" preparation. Other college chemistry courses were marked as "essential" by 50 per cent or less of the teachers.

General Physics I was regarded as "essential" preparation for a high school physics teacher by 99 per cent of the teachers and 79 per cent indicated that the course was an "absolute minimum" needed. Ninety-five per cent of the teachers regarded General Physics to be "essential" and 75 per cent indicated that the course was part of an "absolute minimum" preparation. Modern Physics was marked "essential" by 54 per cent of the teachers and 26 per cent regarded the course as part of the "absolute minimum" preparation.

For the teaching of General Biology, 91 per cent of the science teachers indicated the College General Biology (with laboratory) was "essential" and 63 per cent regarded General Biology as an "absolute minimum." Eighty-four per cent of the teachers responding indicated that General Zoology was "essential" and 63 per cent regarded the course as part of an "absolute minimum" needed to teach high school biology. College General Botany was marked "essential" by 83 per cent of the teachers and 59 per cent thought it should be part of an "absolute minimum" preparation. Human Anatomy and Physiology were marked as "essential" by 63 per cent of the respondents and 30 per cent regarded the course as part of an "absolute minimum."

The next highest ranking course was Biology Materials for Teachers. This course was regarded as "essential" by 41 per cent of the respondents and as part of an "absolute minimum" by 24 per cent of the science teachers. A number of respondents noted that they had not heard of such a course but thought it would be of value. The data suggest that college biology departments should consider developing such a course if they do not offer it at the present.

The results of this survey suggest that science teachers in Kansas recommend a minimum preparation of at least one year of college work in the subject taught. However, no course was regarded as an "absolute minimum" needed to teach a particular high school science by more than 80 per cent of the respondents. This would suggest that some of the science teachers feel that a subject such as physics could be taught without any college preparation in physics. Though this inference may be wrong, the fact that some high school teachers in Kansas are teaching science subjects without a single college course in the science (4) lends support to this inference.

To determine a minimum college preparation in science for high school teachers, we suggest as a base those courses which 50 per cent of the high school science teachers regard as "essential." This would mean that a teacher of general science should have elementary physics, elementary chemistry, and biology. A teacher of high school chemistry should have two courses or one year of basic chemistry, organic chemistry, and qualitative analysis. A teacher of high school physics should have two courses or one year of basic physics, and "modern physics." A teacher of high school biology should have general biology (with laboratory), general botany, general zoology, and human anatomy and physiology. The writers would regard this preparation as not only "essential" but definitely as "absolute minimum" preparation, even for teachers in small high schools where courses are taught by one teacher.

Since the median enrollment in Kansas high schools is fewer than 80 (2), the recommendations from science teachers in these schools should be regarded as a realistic minimum for most states and probably below minimum for states where small high schools are less common. Science teachers, superintendents, and state officials interested in improving high school science instruction should do everything possible to meet or exceed the minimum standards of college preparation suggested by this study.

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TABLE I

Science Teacher Judgments of College Science Courses Needed to Teach General Science, Chemistry, Physics, or Biology in the High School.

Courses Needed	Absolute Minimum No.	Absolute Minimum %	Essential No.	Essential %	Helpful No.	Helpful %	Little Value No.	Little Value %	Number of Respondents
To Teach General Sciences									
Physics I	117	65	162	90	18	10	1	0.6	181
General Biology	108	62	149	86	22	13	2	1	173
Chemistry I	110	60	156	85	23	13	4	2	183
General Geology	32	17	78	43	90	49	15	8	183
Astronomy	26	15	66	38	102	59	6	3	174
Physics II	31	19	62	38	79	48	24	15	165
Botany	32	18	64	36	102	57	14	8	180
Zoology	32	18	60	34	104	58	14	8	178
Chemistry II	15	9	37	22	91	55	37	22	165
Modern Physics	11	7	29	18	108	68	21	13	158
Field Biology	11	6	28	16	124	72	20	12	172
Organic Chemistry	7	4	13	8	100	62	48	30	161
To Teach Chemistry									
Chemistry I (Inorganic)	127	80	159	100					159
Chemistry II	108	68	144	90	16	10			160
Organic Chemistry	80	51	127	81	29	19			156
Qualitative Analysis	46	29	81	50	75	47	5	3	161
Quantitative Analysis	23	14	50	30	102	62	12	7	164
Physical Chemistry	11	7	34	23	95	64	20	13	149
Biochemistry	8	5	21	14	111	73	20	13	152
Advanced Chemistry	3	2	10	7	101	71	32	22	143
To Teach Physics									
General Physics I	123	79	154	99	1	0.6			155
General Physics II	117	75	148	95	7	5			155
Modern Physics	40	26	82	54	68	45	1	0.6	151
Electricity and Sound	28	18	63	41	85	56	5	3	153
Heat and Light	24	16	55	36	91	60	5	3	151
Physical Science	16	11	43	30	79	55	21	15	143
Radio	7	5	25	17	107	72	16	11	148
Nuclear Physics	10	7	22	15	109	72	20	13	151
Intermediate Physics	2	2	15	11	99	74	19	14	133
Electronic Physics	7	5	14	9	113	75	23	15	150
To Teach Biology									
General Biology (with lab)	100	63	143	91	14	9	1	0.6	158
General Zoology	103	63	138	84	26	16			164
General Botany	98	59	138	83	29	17			167
Human Anatomy & Physiology	52	30	108	63	61	36	2	1	171
Biol. Materials for Tchrs.	36	24	62	41	81	54	8	5	151
General Physiology	20	13	55	36	88	58	8	5	151
General Biology (no lab)	27	21	45	35	53	41	30	23	128
Genetics	19	12	53	34	97	61	8	5	158
Microbiology	11	7	39	25	102	66	14	9	155
Entomology	11	7	33	22	99	65	21	14	153
Comparative Anatomy	11	7	25	16	101	65	29	19	155
Animal Natural History	6	4	20	15	94	69	23	17	137
Embryology	8	5	23	15	106	68	26	17	155
Plant Anatomy	6	4	21	14	111	75	16	11	148
Plant Taxonomy	2	1	19	13	103	72	21	15	143
Ecology	9	6	19	13	99	67	29	20	147
Plant Physiology	3	2	16	11	104	72	25	17	145

Teaching VOCABULARY in Biology

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AT one time, I taught biology in a large city high school that is on a two-track program; that is, most of the courses in biology, English, and social studies are divided into what are called college-preparatory and general sections. This terminology is not quite accurate, however. Because of pressure from both parents and peers, most of the students of above average intelligence tend to congregate in the college-preparatory sections, leaving the students of below average intellects (and often those of below average socio-economic groups) in the sections of the general curriculum.

The general biology course was more or less of an experiment in making biology meaningful to the children of the lower abilities, inasmuch as it was the first time that a year of science was required in the tenth grade, it formerly being taken by college-preparatory students only.

When the three teachers responsible for this course compared results after the first six-weeks grading period, we found that our chief common difficulty was one of vocabulary. It should be kept in mind that we had approximately three hundred eighty students whose average intelligence quotient was eighty-five, with a range of from fifty-two to one hundred twelve, and an average reading ability of a sixth- or seventh-grade level. In addition, our textbook, which admittedly was not the best available for this type of class, was written on a ninth-grade level. Clearly, we had a problem.

Our first action on the problem was to prepare a vocabulary list of the words that we thought were absolutely essential to a basic understanding of our biology course. The study of biology can easily become a formidable vocabulary exercise, and so with this group of low ability, we decided to eliminate all of the biological words, even those of moderate difficulty, that could be dispensed with, due to the fact that the students had never had a science course other than general science, and thus this was their first experience with a technical vocabulary.

We evolved the following list of words, which numbers 150, using two criteria as our guides:

1. Are these words necessary to a basic understanding of biology?
2. Is it impossible to substitute other words of a simpler nature for these words?

NOTE: Author's current address—MSU Student Teaching Center, Williard Library, Battle Creek, Michigan.

If the words were essential and could not be substituted we put the words on the vocabulary list. Some of these words, sixty in all, were already known by the students (these words are marked with an asterisk), although rarely could they define the words in terms of functions, which is an important aspect of definition in biology. The list of words follows.

abdomen*
absorption
adaptation
alga
allergy*
anterior
antibody
antitoxin
appendage
aquatic
artery*
asexual
assimilation
bacteria*
biology*
bladder*
blood*
botany
bud*
capillary*
carbohydrate
carbon dioxide
cell*
cerebellum
cerebrum
character
chlorophyll*
chordate
cilia
circulation*
communicable
compound
conservation
corpuscle*
cotyledon
cycle
decay*
deficiency
diffusion
digestion*
dorsal
element
embryo
energy*
environment
enzyme
epidermis
esophagus
excretion
fat*
fertilization*
flower*
food*
function
fungus
gastric
germ*
germination
gland*
growth*
habitat
heart*
heredity
hormone
host*
hydrogen*
infection*
ingestion
inorganic
intestine*
invertebrate
irritability
kidney*
larva
liver*
locomotion
lung*
lymph
mammal
medulla
membrane
metabolism
metamorphosis
microscope*
migration
mixture*
mucous
nerve*
neuron
nitrogen*
nucleus
nutrition
nymph
organ*
organic
organism
osmosis
ovary
oxidation
oxygen*
pancreas
parasite
perspiration*
photosynthesis
phylum
physiology
plasma
pollen*
pollination
posterior
protein*
protoplasm
vitamin*
pupa
reaction*
reproduction*
respiration*
response
saliva*
sap*
saprophyte
secretion
seed*
segment
sensitivity
serum*
sexual*
skeleton*
soil*
species
sperm
spinal cord*
spine*
spore
stamen
starch*
stimulus
stomach*
sugar*
survival
system*
terrestrial
testes
tissue*
toxin
transpiration
variation*
vein*
ventral
zoology

How to Build the Vocabulary

Basically, there are two general methods of building vocabulary: direct and incidental. The direct method would involve teaching the words

that the students should know before entering into a phase of work in the class, and the incidental method would involve teaching the words as they occur and need to be understood. Of course, some of the students all of the time, and all of the students some of the time, would recognize the need to know a word when they encounter it, but this cannot be depended upon, and so the teacher must undertake most of the responsibility of building the vocabularies of the students, especially in the technical fields, where it seems the pupils tend to shy away from words that look too difficult to handle. Since this is the case, the teacher should always keep in mind that vocabulary building "is a means to an end, never an end in itself." (7)

A practical list of suggestions is offered by Russell (8), as follows:

1. Firsthand experiences.
2. Audio-visual aids.
3. Oral language expression and listening.
4. Explanation by the teacher.
5. Oral reading by the teacher.
6. Use of pupil-made materials.
7. Emphasis on concept building.
8. Wide reading.
9. Use of the dictionary.
10. Informal word study.
11. Direct word study.

Firsthand Experiences

In a biology class, firsthand experiences may be found in the laboratory. Certainly the word "digestion" would come more alive to the child as he carries out an experiment in breaking down meat with enzymes and acids. A field trip would certainly tend to give these experiences leading toward vocabulary building. There are many other ways that could be attempted, since a laboratory course lends itself ideally to the giving of firsthand experiences to the child.

Audio-Visual Aids

In the use of films and filmstrips we are cautioned that a good practice is to prepare the pupils for some of the more important new words that they will encounter. Much success will be experienced by the teacher who employs this technique. The same would hold true when we utilize charts, bulletin board displays, and pamphlets. In short, direct the students' attention to the words that they will need to know.

Oral Language Expression and Listening

We must constantly ensure that the students have many opportunities to use these words in

their speech. This might involve questions and answers, reports, discussions, and many other ways to get the child to use the words. At the same time, care should be exercised that the other students profit from this by listening.

Explanation by the Teacher

Many times a day in the biology class, a broad concept must be explained by the teacher, especially with the type of student who ordinarily has great difficulty in generalization. Care should be taken here that the explanation is used as a vocabulary review.

Oral Reading by the Teacher

This technique is always popular in school. Prose and poetry of a non-fiction nature (since fiction tends to become anthropomorphic) has a definite place in the biology class. Once again we are reviewing vocabulary and giving listening experiences to the students.

Use of Pupil-Made Materials

This is an extremely valuable technique, since many of the students truly enjoy the work of making charts, graphs, illustrations, cages, aquaria, etc. For example, a student who makes a chart to explain the whole concept of the word "photosynthesis" will most probably not forget the broad meaning of the word.

Emphasis on Concept Building

As stated earlier, the type of pupil described here has a definite handicap in that he cannot generalize too effectively. Since this is an important ability to have, we continue to try to improve his competency. A word such as "parasite," when carried to its fullest meaning, can involve a concept that includes almost a complete understanding of the whole interrelationship between plants and animals. Both the importance and the difficulty of this purpose of education are at a high level.

Wide Reading

This is a relatively easy technique. Both directed and non-directed readings are done by most students in the area of biology. Magazines, newspapers, and books are utilized continuously. Obviously, the teacher must continue to emphasize vocabulary building on the part of the students when pursuing this activity.

Use of the Dictionary

This would seem to be a part of the technique listed above. Dictionaries should be handy, and

perhaps the teacher must take time to explain diacritical markings, choice of definitions, and other skills to the students.

Informal and Formal Word Study

The study of words, both directly and incidentally, is quite important in an area where many words are derived from Greek and Latin. For example, the idea that "phyte," when used as a suffix, means plant, is an extremely useful bit of information. The study of words within words, prefixes, and suffixes will help the child to achieve an ability to derive meanings from context, which is important in his reading ability and understanding.

CONCLUSION

Finally, it is recommended that students be made aware that the study of a new subject also requires growth and development in the use of a technical vocabulary. It is through this means that information on a new subject becomes more meaningful to them. For those teachers wishing to pursue this subject further, a bibliography follows through which other helpful devices are suggested.

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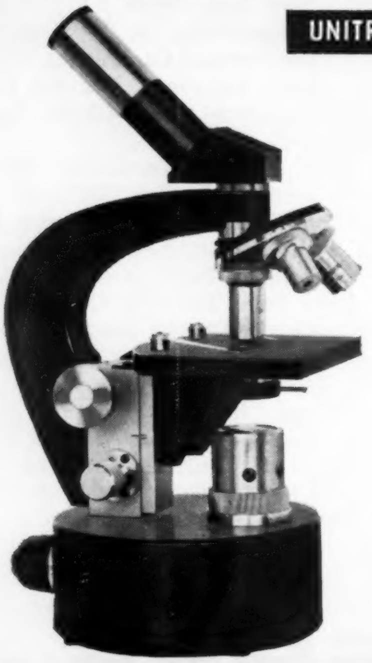

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By **HAROLD E. TANNENBAUM**

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EDITOR'S NOTE: The following article represents the fourth and last of a series continued in TST by Dr. Tannenbaum in cooperation with NSTA's Business-Industry Section. Plans are in progress to have these articles prepared as a reprint pamphlet for distribution. Availability and details will be announced at a later date.

IN round numbers, a science teacher has two hundred periods with a class during a school year; two hundred periods or about one hundred fifty clock-hours. If a teacher used nothing but industry-sponsored aids—films, filmstrips, pamphlets, charts, recordings, books—he would have enough materials to keep his class busy for fifteen hundred hours, let alone the one hundred fifty that he actually has. This is the root of one perennial problem faced by teachers. What materials are worthy of the precious commodity—time, so important in a school day?

But you cannot measure the worth of books in pounds. And you cannot judge films by their footage. No scale has yet been devised which can classify educational materials with a simple, quantitative index. Nevertheless, the many educational aids, both those that are purchased and those that are free, which reach schools and teachers all over the land each year, make it necessary to employ criteria for their evaluation.

Looking at another aspect of the problem, American industry has been generous in its production and distribution of materials for educational purposes. Those of us who are members of the National Science Teachers Association need only recall the many business-industry sponsored packets we have received to find one example of what this service has meant. And these packets are only a tiny fraction of what industries have done for the schools and for education generally. Just in terms of dollars spent, the figure is tremendous. Far beyond the considerable dollar value of these materials is the educational value of a good proportion of them. No business wants to prepare a film just to have it gather dust on a shelf. No industry wants to have its educational pamphlets, the fruit of many hours of work, dumped unceremoniously into a trash basket.

Industry, too, wants the best possible materials which can be of tremendous value in the classroom for present and future uses.

Certainly the standards for producing such fine educational aids are known. At least half a dozen studies have been made on this problem and from these studies have come some criteria for the sound production of commercially sponsored educational materials. One such recent and widely accepted study (Robert C. Lusk. "Principles and Practices for Sponsors of Educational Materials," *The Instructor Magazine*, Danville, New York. 1957) points out these criteria for producers:

1. Sponsored materials should meet the needs of the curriculum, the student, and the teacher.
2. Counsel from recognized educational consultants, special educational agencies, or competent commercial agencies should be used in all stages of the planning, production, and distribution of school aids.
3. Specific uses of the material being planned should be determined before the material is produced.
4. All educational media should be surveyed to determine the most effective and appropriate use or technique for the subject under consideration.
5. The content of sponsored materials should be related to the work or business of the sponsor or to a field in which the sponsor may be considered competent by experience.
6. The content of sponsored materials for school use should be objective; advertising is not acceptable. Credit lines, however, should establish the source of materials and identify the sponsor.
7. Classroom testing and educator evaluation are of great value before materials are produced in quantity; such testing should result in modification where necessary, not in approval as the only yardstick.
8. Re-evaluation should be a continuous process.

9. Awareness of educational trends is important in keeping philosophy and practice pertinent to the changing school situation.

This is sound educational theory and from its application comes sound educational material. But not all industry has adopted these criteria. Some of the material which is distributed violates the standards which should be met.

And on the other hand, some teachers give little or no attention to this material. It's free. We can get all we want. Why take care of it? It doesn't come out of our budget. This view (and it is far too common among teachers) is about as shortsighted as any to be found. For one thing, overcrowded budgets can get tremendous relief from industry-sponsored materials. Viewed carefully, the use of the materials fits right into the pattern of sound education which NSTA has been sponsoring. We want experts for our classrooms. We want experiences with real materials. We want a chance to see the applications of science principles to the solution of society's problems. These industry-sponsored teaching materials can, and generally do, bring such things into being. A well-produced, sponsored teaching aid is really a group of experts coming into the class to help the teacher.

What is it then that needs to be done? From the point of view of industry, the first step is the preparation of the material. Teachers will be the first to agree that industry can best describe what it is trying to do; how it is employing science principles; how these principles are applied to the solution of problems. But teachers can assist in the preparation of these materials. Of course, many industries know this and sponsored materials often are prepared with as much or more professional help than are those which schools must buy. But there are still those materials which are thrown together without concern for their educational worth and with more interest in the number of times that the sponsor's name appears than in the content of the pamphlet. What teachers ask is: "Please use the criteria which have been so carefully established. We can accept those criteria and the resultant materials."

There is another complaint which teachers have. Many industries, because they wish to reach as large a group of potential consumers as possible, prepare general and vague kinds of materials. This kind of "shotgun" approach to the educational market is quite disturbing to science teachers. Frankly, teachers have more use and more respect for educational materials when they are directed toward a precise group and have a specific educational purpose than when such materials try to "grape shot" the entire gamut of the school system or even of the population. When industry spends several thousands dollars for a film or for a kit, it should be usable for specific teaching. Vague and generalized platitudes are not desirable.

Now, how about the teachers? Here are a few questions to be answered. When you buy a filmstrip for your school do you treat it with care? Of course you do. A filmstrip costs three dollars or more. The ones that come from industry cost that much too. When you buy a pamphlet series for your class, do you treat it with care? Certainly, because each pamphlet costs fifty or seventy-five cents and a set for the class costs fifteen or twenty dollars. A set of pamphlets from industry costs fifteen or twenty dollars also. Many industries are willing to supply your needs. That is why they publish these materials. But they ask that these materials be used—not wasted.

Then there is the matter of creativity in the use of materials. Finding the unique way to use these education materials with *your* class is a very important responsibility. Even assuming that the materials are the very best that can be produced, it does not follow that the materials will "teach themselves." Teachers must find the special ways to use any given set of materials which best serve their particular purposes and their own classes. Just as experts are brought into class to do a special job, just as field trips are taken for particular and unique purposes, so these sponsored aids should be examined to determine the unique job that a particular set of materials can perform. Thus, it is the teacher's responsibility to evaluate these materials and use them only when and as they fit into his program. This careful evaluation should consider, first of all, the appropriateness of the educational material. Does it meet the needs of the class? Is it written with a vocabulary which

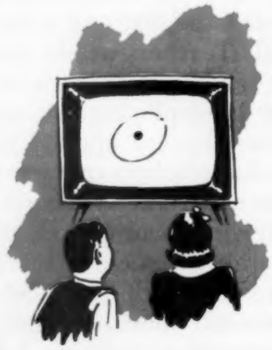
the children can understand? Are the concepts presented accurately (which is likely) and, a question needing much careful examination, are they at a level which is appropriate for the class? Then there is the matter of class objectives. The most beautiful, the best prepared, the most carefully produced materials are of little value if the materials are aiming for one set of objectives and the teacher and class are after some other set.

There is also the matter of variety of points of view. Every issue, every question, every problem in today's world almost inevitably is interwoven with science concepts. It is extremely difficult for anyone to separate his point of view on an issue from the science facts or concepts related to that issue. The president of one of America's largest public utilities told a group of teachers recently: "The truth of the matter is that whether an electric company is run by a privately owned group or by the government, the science involved is going to be the same. Sound science and engineering practices are not the sole province of either private engineers or government engineers. But we people who are in the utility business know that private ownership is better." Now, what is the teacher's responsibility in such a situation? It is simple. He must, on the one hand, make clear the science which applies. On the other hand, he must give all points of view a fair hearing in his classroom. And the teacher must make sure that all get a hearing. There can be no question of leaving the social implications out of science. Rather, it is a matter of seeing that the questions are fully and rationally considered.

Many other aspects of industry-sponsored science materials need equal attention. While it is true that films which are used by companies for mass distribution often do not have too much classroom appeal or use, with special presentation on the part of the teacher such films may be adapted to the classroom. In this situation there are two things industry can do: first, let teachers know about what is available; second, adapt general advertising materials for classroom use when such adaptations are possible. Without too much difficulty many of the broad, general films can be interpreted to fit the specific needs of schools, and both the schools and industry will be well served.

But there are far more educational materials prepared and sponsored by industry than just those pamphlets, films, kits, and other items which can be brought into the classroom. Companies are spending millions of dollars on mass media science programs. In the past several years, television programs have contributed enormously to the understanding of recent developments in science. These programs have not only been presented to mass television audiences. They often have been made available for school use through the production of kinescopes of the original programs. Even without such kinescopes, teachers can and should use television programs in their teaching. There are also regularly scheduled television science courses such as "The Continental Classroom" (in atomic physics) which are partly sponsored by industry and which can be of great use to the teacher for his own self-improvement or to the students for enriching the school program.

Assigning a television program for homework is not at all undesirable if the program can give the students understandings which they need. This certainly means that teachers should be alert to the possibilities, and that industry can help considerably by keeping teachers informed through various channels of communication when such science programs are being produced. For example, the brochures which have announced the Bell Telephone Science Programs and which were sent out to all NSTA members were very helpful to teachers. The reactions, evaluations, and suggestions sent back by teachers after viewings should be useful in the production of future programs to meet their needs.



There is a real need for continuing cooperation between educators and industry in producing and using educational materials. In such ventures, each has his role to play. Industries should continue to call on school people for professional assistance in the preparation and evaluation of school materials. Industries should apply accepted criteria in the production of all school aids. Furthermore, while industries cannot (and

generally do not want to) use these materials as advertising media, it is desirable that the producers be identified. The industry or trade association which has produced a science aid should take the responsibility for it and thus receive either the brickbats or the bouquets which the teaching aid may elicit.

Education has its share of obligations. Teachers must give of their professional experiences so that the subject matter chosen and the materials produced are the best that can be devised. Both as individuals and as organized groups, educators should examine their needs and inform responsible industry groups (B-I is one such very important group) what these needs are. In this way, industry is much more likely to produce that kind of material which will be of real service to science teachers. Furthermore, teachers must use such materials carefully and with as much respect and frugality as if they had been bought from a low school budget. There is no such thing as free material. Eventually, materials must be paid for and their cost comes from the productive resources of the economy. The somebody who pays is us—all of us. Careless or wasteful use of our materials ultimately means less for our children. But conscientious production of educational materials and careful use of such materials can make partners of educators and industry in providing vast and valuable resources for our schools.

Hints for Industry

1. Carefully thought-out criteria for producing school materials are available. Have you become familiar with them?

2. Your educational materials are going into public schools. Perhaps the best question you can ask yourself is: "If I were a parent or citizen not connected with this company, would I want a child of mine to use this material?"

3. You are producing educational materials—not advertising brochures. Stress concepts and information which are related to your story.

4. Teachers and educators know how ideas may best be interpreted to children. Call on them for the expert help which will make your materials most valuable in the school.

5. The quality of production will make a tremendous difference in the reception of your material. An attractive and well-produced brochure will receive far better attention than will a poorly produced one. This does not necessarily mean greater cost, just attention to layout and format.

6. Let the teachers know what materials are available so that they may be requested early enough to be used at the proper time in the school year.

Hints for Teachers

1. Sponsored materials are being produced at an enormous rate. You will do well to examine the possible industrial sources of films, pamphlets, filmstrips, and charts when you plan your work. Chances are that with careful review you will find material that you can use.

2. Whenever a sponsored aid concerns itself with a controversial issue, the teacher has an obligation to present to the children *all* of the points of view on that issue.

3. *Do* inform the appropriate people about your use of their materials. They will want to know how the materials were used and will welcome your reactions to the effectiveness of the materials. And don't forget to get the students' reactions. This information is most valuable to the producers. When you find the material really useful, as you often will, praise it. A note of thanks is always very welcome.

4. Free material is far from free. Use it with care. Conserve it. Do not order more than you know is required.

The Annual B-I Award was presented for the first time by (l.) Julian Street, Jr., Chairman of the NSTA B-I Section, to the National Broadcasting Company for its educational TV program "Continental Classroom" on Atomic Age Physics. Mrs. Dorothy Culbertson, producer of the program and a member of NSTA B-I, accepted the award for NBC, with Harvey E. White (who taught this series), Professor of Physics, University of California.

Physics Laboratory Can Be Fun!

Science teacher Fred D. Reinolson explains atomic

By FRED T. PRE

Associate Professor of Physics, Trenton State

THE course is our one-semester freshman general education course in Introduction to Physics for people with no physics background. The object is to motivate students not having had physics in high school and confronted with it during the first or second semester in college.

The Problem

Our philosophy at Trenton State is that all science courses should have individual laboratory work, whenever possible. After having taught physics in high school and in college for some six years, I had concluded that the usual opening laboratory exercise on measurement, the vernier caliper, and density is a deadening experience. It occurred to me that perhaps a more lively first laboratory experience could be devised and the measurement laboratory postponed. The problem, then, was essentially this: How can laboratory work be introduced in a meaningful way? This work should fill the following criteria:

1. Offer a challenge.
2. Be interesting—fun to do.
3. Be relatively simple and straightforward in procedure.
4. Involve operations that are basic to science—important to understand.
5. Be reasonably sure of good results.
6. Serve as a basis for class discussion.

At the outset, I might say that I am sure these criteria and the subsequent solution offered are equally valid in the high school physics course.

A Solution

The laboratory exercise devised to solve this problem was entitled "The Technique of Calibration and Its Application." The experiment is essentially a modification of the standard Hooke's Law experiment but with an entirely different emphasis and point of view. As a matter of fact, if Hooke's Law is mentioned, it is entirely incidental. The apparatus is the simple Jolly balance, a set of slotted weights, a beam balance, and an "unknown" weight—any old clamp or piece in the room.

Essentially the procedure is this. Weights are added to the Jolly balance and the extension of the spring measured. Enough readings, starting with no weight and no extension, are made to give about ten measurements over the length of the scale. A curve is plotted of weight *vs* extension and this is used as the calibration curve for the balance. An "unknown" is placed on the balance, the extension measured, and from the calibration curve the weight of the unknown is found. This is then checked by weighing the unknown on a beam balance. (If there is no strong emphasis on "getting the right answer," but on being as careful as possible and "seeing how close you come," there is no cheating.) I always caution the students not to spoil the fun by weighing the unknown on the beam balance before beginning the experiment.

SHELL OIL COMPANY

n explains atomic energy to student Loretta Wasson.

FRED T. PREGGER

ics, Trenton State College, Trenton, New Jersey

Using the criteria established above, this experiment:

A. Offers a challenge—
   1. The apparatus is new to the students and it looks interesting.
   2. After learning about the handling of the apparatus, the student discovers that he can use it for a purpose, the weighing of something unknown. This gives a surprise ending.
   3. The student discovers difficulties in measuring caused by parallax, uneven hanging of the weight holder when weighing the unknown, and the oscillations of the spring.
   4. The results must be interpreted. The meaning of the calibration curve must be understood. This is not a case of filling in the blanks.

B. Is fun—

The students like to use an unknown. They discover that they have actually made a scientific measuring device and one which is common to their experience, and it works. Comments are always heard, "That was fun" or "I liked that," etc.

C. Is relatively simple in procedure—

Yet not too simple. Basically this is very easy apparatus to handle. However, care must be used in keeping the weight hanger level, avoiding parallax errors, plotting a valid curve, avoiding the moving of the scale relative to the weight hanger support, and others.

Only two basic concepts are involved, the meaning of calibration, and the extension of a spring under an applied force. In like manner, the operations are few and simple.

D. Illustrates a very important basic operation—

Every measuring instrument used must be calibrated at some time. It is good to know the meaning of this and how it is done. This leads to the understanding of standards, and of course, shows one important use of the plotting of curves.

E. Produces consistently good results—

It is important that the beginning student achieve success in his first efforts in physical experimenting. The results in weighing the unknown are for the most part under two per cent in error. This also gives practice in determining percentage of error and can lead into an understanding of the meaning of this expression.

F. Gives a basis for class discussion—

The experiment can be used to show the meaning of a number of items as brought out

Learning to handle new apparatus does not daunt these students.

BERKLEY PUBLIC SCHOOLS, MICHIGAN

in discussion. For example, it shows a law (Hooke's) and its mathematical formulation as taken from the data. It shows the meaning of proportion and linearity in related data.

The curves which are linear except near the origin can be used to bring out many questions such as: the reason for the deviation from the straight line near the origin, why all students do not obtain the same curve although all the curves are of the same form, the plotting of curves through the points but not necessarily touching all points, extrapolation and interpolation, and others.

It shows the need for standards and the technique of how any instrument is calibrated. These steps are important in planning any activity in the laboratory.

In short, I believe that this is a good beginning experiment for the physics class. It works well for me. Try it and see for yourself. Our laboratory directions for this experiment are given in detail below.

The Technique of Calibration and Its Application

Purpose: To study a simple method of making measurements through the use of a calibrated measuring device and a curve.

Apparatus: Jolly balance, weights, graph paper, unknown weight.

Introduction: Many measurements, even those which are commonplace, involve indirect measurements of quantities other than that which we wish to know. For example, a thermometer indicates temperature by measuring the *length* of a column of mercury. In this experiment, we shall make a measurement using such an indirect device.

Many common devices of the type indicated have the indirect measurement printed on them. For example, the average thermometer has the glass tube marked off in degrees rather than inches or centimeters. If this were not so, we would have to read the temperature as so many centimeters and then convert to degrees by knowing how many degrees are equal to 1 cm on the scale. Obviously this would be inconvenient for the average thermometer. However, a printed scale of this type limits the instrument to just one use, and makes it difficult to adjust for very accurate readings should it be not quite accurate enough.

Consequently, in the laboratory, it is common to have a scale read in whatever basic units it measures and then convert the readings to the desired units when it is in use. In this way, one basic instrument such as an ammeter can be used to make many types of measurements.

The process of calibrating and using an instrument is described in the following steps:

1. Making the desired measurement using known standard values.
2. Observing the readings of the instrument for the standard values.
3. Preparing a chart or table of instrument readings which correspond to standard values. If the instrument is to be used only for the one purpose, these values will be printed on the indicator of the instrument. Otherwise they are kept for ready reference. Often it is desirable to plot a calibration curve—a graph of the instrument readings against the standard values. Then in actual use, it is very easy to translate an instrument reading into the final measurement by simply reading the graph.
4. The instrument is then used to make the desired measurements, and the values of the reading are determined from the instrument scale and the calibration table or graph.

Procedure: CAUTION—It is extremely important that the positions of the reflecting scale and the spring support are not moved once the experiment has begun.

a. Set the Jolly balance to read zero with no weights applied. Determine the weight that causes nearly full-scale extension of the spring by adding weights to the weight holder. Remove the weights and reset the spring to zero. Divide this full-scale weight by a factor of 10 so that a whole number multiple of 5 results.

   Example: Full-scale reading is 260 grams

   $$\frac{260\text{ grams}}{10} \cong 25\text{ grams}$$

   This result is the amount of weight you will add to the weight holder for each successive trial. Thus you should have 10 trials in all.

b. Be sure that the spring reads zero with no weights on the holder, then add the small amount of weight that you determined in procedure (a). Read the extension of the spring and record the

weight and extension. Add the same increment of weight to the holder and read the new position of the spring. Continue this procedure until you have 10 values and extension.

c. From these readings prepare a table of weight against scale reading and construct a calibration curve. To plot the curve choose on your graph paper convenient scales for weight and extension. These should be chosen so that they are as large as possible within the limits of your measurements and divided in some *easy* way to read. (Use 10's, 5's, 2's, 1's, 100's, etc.) Plot the independent variable on the X axis (in this case, the known weights), and the dependent variable on the Y axis (the scale reading). Plot all points as tiny circles, squares, or triangles, and connect them with a *smooth* curve passing through most of the points.

   On any graph, the following items *must* be included, and the graph *neatly* done.

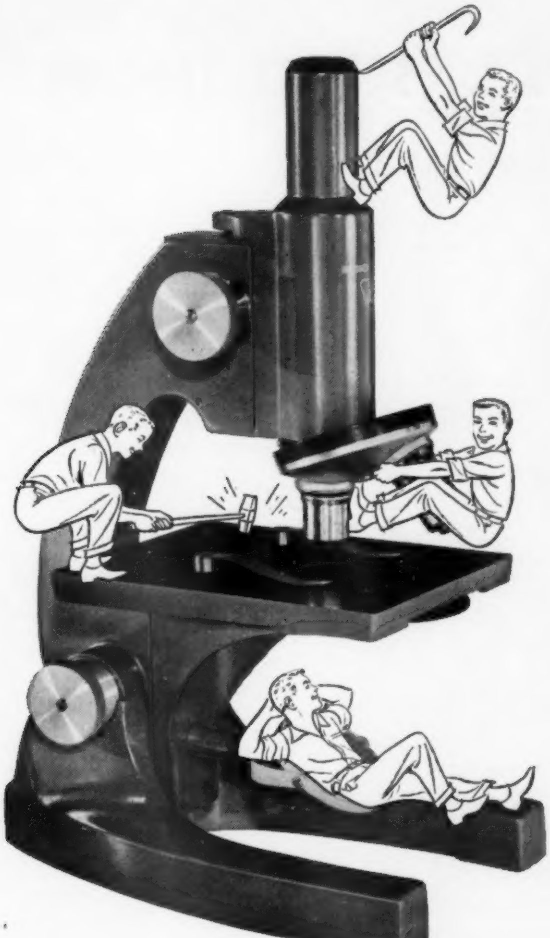
   Title—what the graph shows.
   Scales clearly marked and units given.
   Curve properly drawn.

d. Place an "unknown" weight on the balance, read the extension of the spring and from your calibration curve, determine the weight of the object.

e. Weigh the object on the beam balance, compute error and per cent of error from the beam balance reading.

Questions:

1. What is the advantage of a calibration curve over a table of calibration points?
2. What common instrument works on the spring extension principle used in this experiment?
3. Why is it important not to move the scale during this experiment?
4. Will your results and calibration curve necessarily be the same as the other members of your class who are working with different springs? Why?
5. If you were repeatedly using this spring, how often would you have to calibrate it?
6. Give five common measurements which are made on calibrated instruments. (These will normally be direct reading, i.e., the values you are measuring will be printed on the scale.)



Shoebox Science Fair

By ELIZABETH HONE

The Conservation Foundation's Curriculum Center, San Fernando Valley State College, Northridge, California

I TEACH a course entitled "Teaching Elementary Science" to afternoon and evening college classes. Most of my students teach elementary grades during the day. This semester we decided that individual projects would be more useful than a final examination. Based on suggestions from students in previous courses, we decided to assemble and organize teaching materials in "shoebox kits."

A "shoebox kit" is a box of materials assembled for the teaching of lessons within an area of science. For example, in preparing to teach a unit in the area of electricity, one might assemble wire, dry cells, miniature light sockets, etc., for use in constructions; discarded household electrical equipment for exhibit or disassembling purposes; samples of conductors and nonconductors, a fuse, and some construction materials to illustrate the principle of a fuse. The box might have to outgrow a shoebox to include useful references such as the Boy Scout merit badge pamphlet on electricity, Westinghouse comic books on electricity, posters and charts from a battery company. It might also include write-ups and rough sketches of simple experiments, complete with footnote references. A student in an earlier class pasted these experiment sheets on shirt cardboards and covered them with Saran Wrap. His experiment card file motivated some children in his enrichment class for gifted not only to use the cards freely, but to add to them.

The students were free to choose any area of science they wished and to develop the project as best fitted their own teaching situations. The material did not necessarily have to fit a shoebox. In fact, several projects outgrew them. A shoebox was merely a basic unit. We had learned to use them early in the semester in reorganizing, as a learning experience, the simple science equipment available in our classroom.

On Shoebox Evening, when all of the projects were displayed, the students came burdened with boxes of all sizes bulging with intriguing objects. As each exhibit was set up, it was given a numbered card. The students had developed a personal interest in each other's work, and soon they began moving around and visiting with each other to discuss the materials on display. The students were supplied with blank cards on which they could make unsigned evaluations of one or more exhibits. It was suggested that this evaluation be made primarily on the basis of teaching practicability.

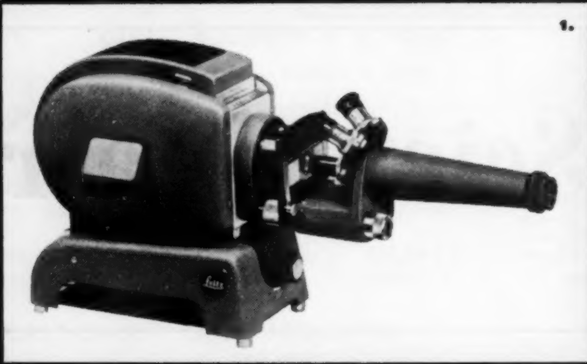
Here are examples of the students' comments about some of the 24 exhibits on display.

Heat. Excellent. Includes all the necessary concepts of heat. It is well planned and illustrated. The experiments are explained in detail.

Electricity. Very complete. Takes beginning concepts and develops them. Leads into advanced experiment in electro-plating. Very versatile. Could be adapted for almost every level.

Light. Wealth of materials. Not all the work already done for the children and yet everything there for them to discover. Very interesting. Shows an immense amount of preparation.

Sound. Tin can telephones good as a simple demonstration of sound vibration in any grade. The water glasses could furnish a lengthy experiment in getting just the right pitch.



switch in seconds *from projection of microscope slides to projection of transparencies with the*

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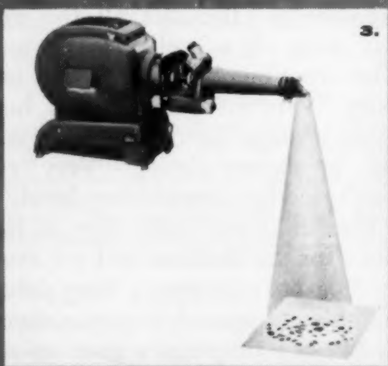
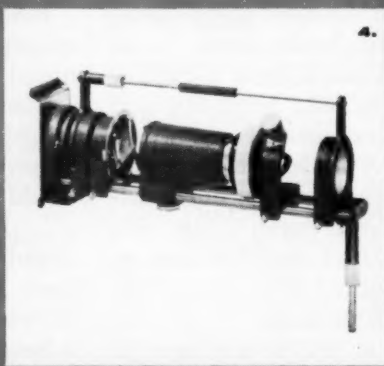
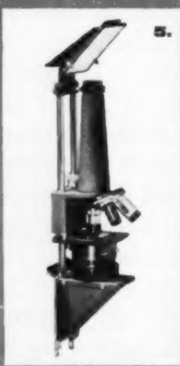






It was interesting to me that the student evaluations agreed in general with those of my own. My criteria had included originality, organization, and evidence of effort in preparation. I felt that the students had achieved a basis of discernment for quality and usability of science teaching materials. However, there were a few exhibits whose "teachability" was not obvious except to an experienced observer. This was one reason I took the risk of appearing to bestow accolades by calling upon a few students to select and describe a particular feature of their exhibits. For example, one showed us all the materials she had assembled which could be used by children in collecting insects and in constructing observation cages.

One of the valuable byproducts of the Shoebox Fair was the indication to the instructor of hidden talent in some students. The value to the students was the opportunity for enrichment and interchange of ideas. Two students found they had both selected the subject of atoms, and each had approached it differently. There were three projects on simple machines, all quite different. One student who had an interesting exhibit on gears, and another who had one on machines, discovered interesting interrelationships and possibilities for follow-up work between them.

Of the 24 projects, I was interested to see that the majority was in the area of physical science. At the beginning of the semester I always plot on the board the high school and college science education of the group. This we do under these six headings: astronomy, botany, chemistry, geology, physics, and zoology. These headings were listed in Craig's original study as areas in which teachers should have training in order to answer children's questions. A class breakdown usually falls into the categories as noted in the table shown.

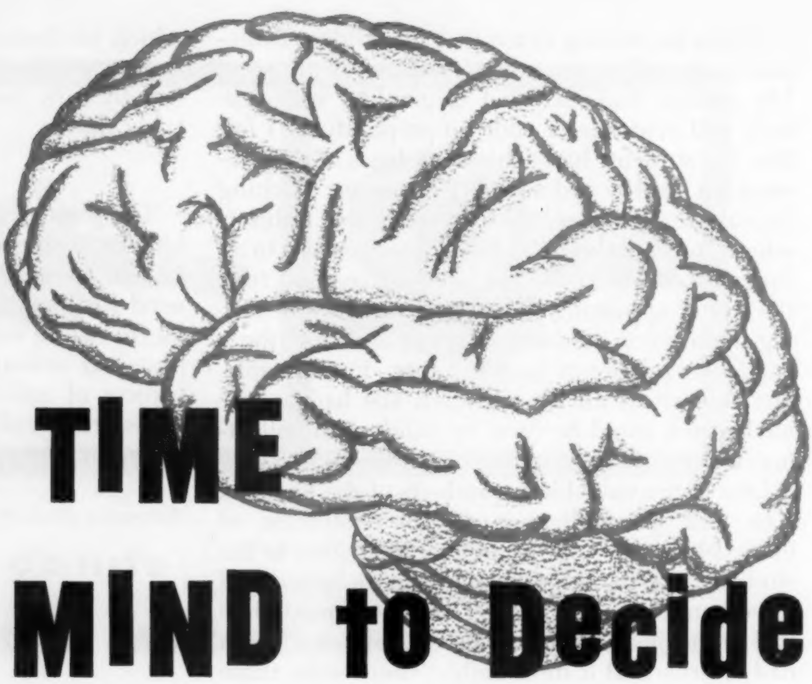
Areas of Study

The present group typically came out heavy in biological science, and with little formal education in physical science. We always discuss the need for maintaining a balance in our teaching, all the while reinforcing our own weaknesses in physical science. The group's unstructured choices of individual projects perhaps reflected an awareness of the imbalance in the training of most elementary teachers in service today.

Astronomy	*Botany**	*Chemistry*	*Geology*	*Physics*	*Zoology**
xx	xxx	xxx	xxx	xx	xxx
	xxx	xxx		xxx	xxxx
	xxx	x			xxxx
	xxxx				xxxx
	xxxx				xxxx
	xxxx				xxxx
	x				

* Biology courses counted here.

In evaluating the activity as a whole I would another time ask each student to hand in a one-page summary of his or her exhibit. I would encourage the students to bring guests (both old and young). If the group included an amateur photographer, it might be possible to secure visual records of some or all exhibits. I would ask the students if they would wish to place related exhibits, e.g., on electricity, side by side. No doubt my students will suggest other improvements. Many of my most effective ideas were supplied by able students who in successive classes have taught me in turn, while I essayed as their instructor to open some doors for them into the fascinating world of science.



It Takes TIME for the MIND to Decide

By HANOR A. WEBB

Professor of Science Education, Emeritus, George Peabody College for Teachers, Nashville, Tennessee

IN one of NSTA's "How I Do It" sessions (New York meeting, December 30, 1956), I demonstrated a very simple method of measuring mental reaction time by means of two pendulums. Since then, letters have come to me from time to time asking for written details of the exercise, showing the action, the calculations, and some aspects of the interpretations.

The Equipment

Two pendulums are used, one slightly shorter than the other. These are readily suspended, some six inches apart, from a rod passing between two chairs. A length of about three feet will clear the table, upon which chairs, with their legs on books, are placed for convenient working height.

The pendulum bobs should be compact and fairly heavy; smooth stones serve well. Any stout, light twine will support these, looped and tightened over the rod (as a broomstick). The bobs should be neatly tied. A short bit of twine from each bob's knot will serve as a finger hold.

The measurements begin with timing the swings per minute of the longer pendulum. A "swing" includes a forward and backward movement. The timing should be accurate, using a clock or watch with a second hand. At least three counts should agree. Counts between twenty-five and thirty-five per minute are typical.

The second measurement is made by releasing both pendulums at the same moment. One person must do this. The shorter pendulum swings faster; in due time it gains one swing on the longer pendulum, and the two swing back precisely together. The count of swings of the longer pendulum must be accurate, with at least three counts agreeing. About twenty-five is close to the right number.

A simple calculation is now in order. In the tests on the reaction times of two eighth-grade students, Judy P. Pewitt and David T. Tucker (see picture), these were the counts and computations.

The long pendulum swung 33 times per minute; time of each swing, 60 seconds/33 swings = 1.82 seconds.

The short pendulum gained one swing in 23 swings of the long one; gain per swing, $1.82/23 = 0.079$ seconds.

The Quick Mind

Judy, testing David's speed of reaction, will hold the longer pendulum back by its short string; David, under test, will hold the shorter pendulum back, with the bobs even. They should be back far enough to give good, but not excessive, swings. The first test will be to measure the simplest possible mental reaction—response to the stimulus of sight. The moment David sees Judy let go, he turns his string loose also. They count the swings of the long pendulum until the two pendulums come back together again. Three counts that agree should be made.

In the first two trials, the shorter pendulum (David's) caught up with the longer one (Judy's) in four swings; in the next three trials, three swings. Experience helps. David's mind responded to the stimulus of sight in 3×0.079 seconds $= 0.237$ seconds. Judy, after the first few trials, responded with three sets of three swings each. It takes time—about one-fourth of a second—for a young mind to follow a stimulus with action.

The tests that came next were also simple. David, then Judy, responded to a sound—the word "Go!" As "judge" I watched closely to be sure that the long pendulum was released at the moment the word was sounded. The results after a few trials leveled off at four swings each for the young folks. The calculation, $4 \times 0.079 = 0.316$ seconds. When the stimulus was a touch on the arm, 4 swings, or 0.316 seconds, were also the results noted in this test.

It is doubtful whether precision after the first decimal place—0.1 second—is significant. If you wish to avoid calculations altogether, you may obtain readings direct in tenths of a second by adjusting the long pendulum until it swings forth and back exactly 30 times a minute. (It will then be one meter, or 39.37 inches in length.) Now adjust the short pendulum until it gains one swing in precisely 20 long pendulum swings. The gain of one swing, 2 seconds$/20 = 0.1$ second.

Scores of tests, which I have made since I first learned of this method of measurement in 1905, indicate that approximately three-tenths of a second is needed by the mind to follow a simple sensory stimulus with a motor reaction. But not all of the mind's decisions are as simple.

READY FOR SWINGS—David Tucker and Judy Pewitt, eighth-grade students in the Donelson (Tenn.) Junior High School. Judy, holding the longer pendulum, will measure David's reaction time in various tests, as described in this article. Then it will be David's turn to measure how fast Judy's mind works.

Mind, then Muscle

David, then Judy, were tested by word opposites; that is, to "black" the response "white" must be given. Single-syllable opposites were first used, as fast (response, slow), low (high), up (down), soon (late), and the like. There are plenty of these pairs, and they serve better than two-syllable opposites as over (under), upper (lower), coming (going). Polysyllables should be avoided, since the time consumed in pronouncing them is considerable.

The averages of some six or eight tests of opposites were these: David, 0.5 second; Judy, 0.6 second.

Now came a real testing of the young folks' mental powers—arithmetic! The test was set forth thus: Judy calls a number less than ten; David will speak the number that will give 10 when added. Example: Judy, "three!" David, "seven!" Each release a pendulum at the moment of speaking. The judge (myself) made sure that David's release was not at the moment he heard the sound; on such occasions (and there were

several) the swinging pendulums were stopped. After David and Judy had both been tested, among the results were these: adding to 5 to make 10, David, 0.8 sec., Judy, 0.5 sec.; adding to 6 to make 10, David, 1.2 sec., Judy, 0.5 sec.; adding to 7 to make 10, David, 1.3 sec, Judy, 0.4 sec.; adding to 8 to make 10, David, 1.1 sec., Judy 0.4 sec. For whatever the reason may be, David had to admit that Judy's skill in mental arithmetic was somewhat greater than his own. As expected, a bit of teaching ensued.

Picture cards of animals were shown next—a rooster, deer, pig, cow, cat, dog, fish, bear, and others. The time required to identify and call a name varied greatly for both Judy and David, from 0.6 second to 1.2 second. Apparently the quality of the drawings was of considerable influence in the reaction response.

There were more tests, of course—but I am giving instructions, not reporting research. For example, the demonstration using opposites is but a variant of the psychologists' favorite game of associated ideas; when one word is called, respond with the next word that comes to mind. This not only measures quickness of thought but also a good vocabulary. It never fails to amuse an audience as unexpected associations are spoken; this, of course, is one aspect of a good demonstration.

Problems requiring real discrimination, and time for the mind to decide, are numerous. We have tried some with philosophical slants, such as these: Which is better (the word in italics is called at the moment of release); accuracy or *speed*? calmness or *vigor*? to be solemn or *gay*? to marry Robert or *John*?

This demonstration has been used at assembly programs, science fairs, at parent-teacher meetings, as including both information and interest. At the PTA meetings certain adults have been bold enough to match their own mental agility with that of their own progeny. What a research study *that* would make!

This device of the pendulums has been used, with refined equipment, in serious psychological research. The technique may have originated in the German psychological laboratories in the '90's. For my students and myself, however, the entertainment value has made the information quite interesting. This demonstration can be quite stimulating to thoughtful young people of high school age as a personal test—"how fast does my own mind work? By practice, may I train it to work faster?"

Classroom Ideas

General Science

How To Produce Lava Flow

By RUSSELL PENGELLY, 1935 Painter Street, Klamath Falls, Oregon

A problem that has confronted me many times as a general science teacher is how to produce a lava flow in a model volcano. Ammonium dichromate to make fire and ashes has been used as a standard procedure. My method is as follows:

Start with a cake of dry hand soap. Scrape off about 25 cc of finely powdered flakes. Obtain about 10 cc of sodium peroxide and 1 cc of manganese dioxide. Thoroughly mix these ingredients. Put the mixture into a metal cylinder of about one inch in diameter and add a small amount of water. From the tube will flow a gray mass of liquid suds. Some experimenting may be necessary, however, to get a light consistency. Heat from the chemical reaction will produce steam and simulated puffs of smoke.

Developing Scientific Concepts

By ROBERT D. KETELLE, Shafter High School, Shafter, California

Having an interest in showing the relationships between the various fields of science, the following lesson plan or demonstration, with its suggested title, was developed. It is submitted for the interest of other teachers in general science instruction.

I. Materials and Procedure

A. Find two or three hollow spheres. The second (Figure 1) sphere (perhaps they will all be hollow rubber balls) should be twice the diameter of the first, and the third sphere, three times the diameter of the first sphere.

B. Fill spheres with water, showing your students the amount necessary, as in Figure 2. Now fill the second ball, recalling that this ball has twice the diameter of sphere 1, and note expressions of surprise when it is discovered that eight times more water is required. Some of the youngsters may think of the demonstration as a kind of paradox, that is, "How can something be twice as *large* as something else and yet be eight times larger." At this point even the curiosity of the more primitive mind is usually awakened (i.e., he thinks the wind blows because it blows itself). The instructor now proceeds to fill ball (sphere 3) which is found to hold twenty-seven times more water than the first ball or sphere.

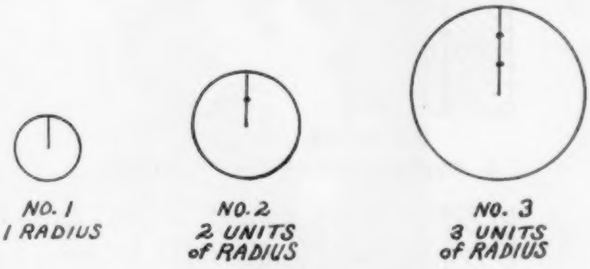


FIGURE 1

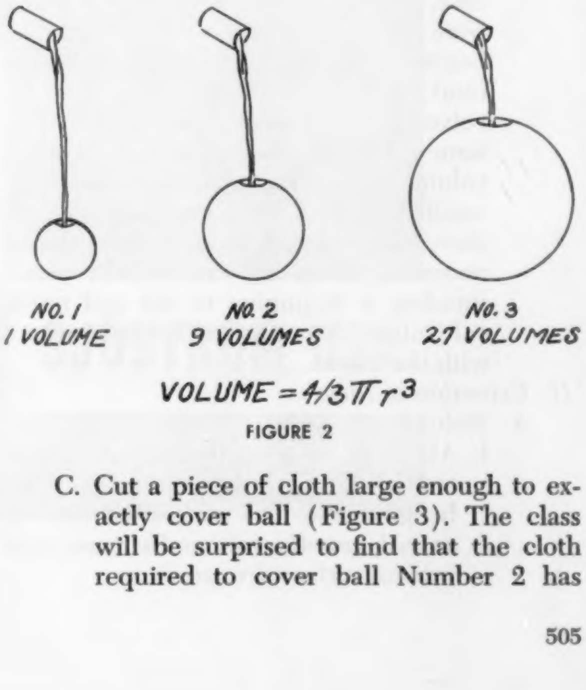


FIGURE 2

C. Cut a piece of cloth large enough to exactly cover ball (Figure 3). The class will be surprised to find that the cloth required to cover ball Number 2 has

four times more surface area than cloth used for the first ball, and they will soon reason that the surface area of ball in Number 3 might be nine times that of the

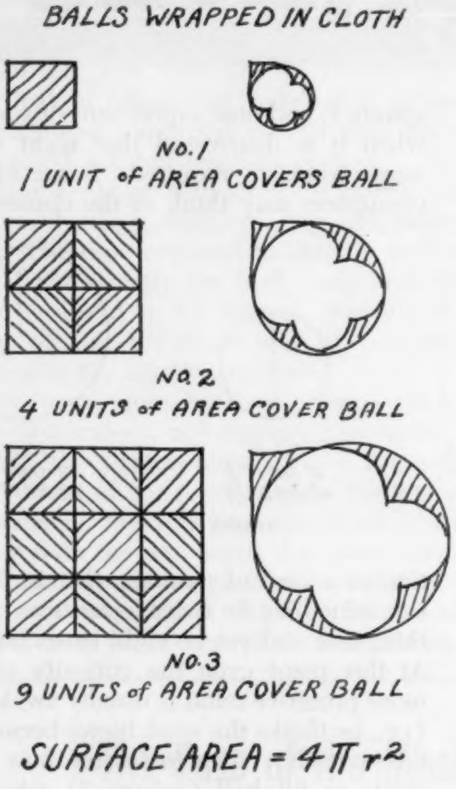


FIGURE 3

first ball. It can be shown that this is the case. To some of the pupils this is magic pure and clear; to others a new concept is beginning to form. In short, they are thinking there might be some unity involved here after all; they realize that some relationships seem to exist between volume and surface area; the words large, small, big, and little are beginning to show ambiguity. A facet of undeveloped reasoning power and dimensional understanding is beginning to stir and needs cultivation. Now the teacher commences with the lesson.

II. Extension of Ideas

A. Biology

1. Although your students realize that animals are not spheres, they can soon be guided to the conclusion that in animal growth, volume increase soon outruns surface area increase.

   a. Who loses more heat per unit of weight, an adult or a child? The answer, from some bright pupil, will be the child because he has more surface area exposed per unit of weight. Why do children *seem* to have more colds than adults? (The teacher may now notice the formation of conclusions with reckless abandon, and this is an opportune time to point out *what the scientific method is not.*) What do your students feel is a factor in the great destruction that is often caused by small animals such as birds and mice?

B. Physics

1. Dealing with the more impractical, a guinea pig will fall faster (in air) than a giraffe because a guinea pig has more surface area exposed for friction, per unit of weight, than the giraffe.
2. The energy of heat and light is often dissipated in concentric circles. We say the energy of heat and light decreases as the square of the distance from the source increases. Our demonstration, with help by the teacher, clearly shows that this is the case.

C. Chemistry

1. It is true that a factor in most reactions is the surface area of the reactant. In general, (S.T.P.) the greater the surface area of the reactant, the more rapid the reaction. Finely granulated sugar dissolves more rapidly than sugar in chunk form. Other factors being equal, it is easier to light a sliver of wood than a telephone post. We note that the *kindling* temperature of the former *is not lowered.* Here we are again faced with a volume-surface area relationship.

D. Miscellaneous

1. One might consider the price differential in food products which have been endowed by nature with a spherical form, that is, in the event these items are sold by the dozen.

III. Conclusion

A. One aspect involved in the study of science is the study of relationships. No

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field of science is a self-contained entity; biology is not divorced from physics and mathematics, even in dealing with the fundamental structure of living things, and especially, science is not just a group of facts devised for rote memorization. We should remind our students of the well-known three-legged stool. How can a boy or girl neglect his mathematics and understand science, that is, really understand it? How can he neglect his science and gain the full significance of mathematics? How can he neglect either science and (or) mathematics and understand the world in which we live?

But a science teacher need not go off the deep end. To say that no field of science is a self-contained entity does not mean quantitative analysis is related to (say) taxonomy. There is no relationship between the two, and one need not exert himself trying to find one. Rather, as teachers of the most basic of the sciences, let's search for the host of integrations involving ideas which serve to link the various fields of science. These links must be scientifically valid, that is, reservation to trickery or deceit to establish pseudo-scientific, vague, and nebulous connections can only serve to lessen the effectiveness of the teacher. On the other hand, if the teacher can really show that in many cases science is not a disjointed mass of material, then teaching can be facilitated by making science more meaningful in terms of teaching what science is, where science came from, and some of the basic concepts involved in science.

CONVENTION NOTES

• MAJOR SPEAKERS

The array of speakers for general sessions and meal functions at KC shapes up as perhaps the most varied and imposing of all NSTA conventions. The cast, in order of appearance, is as follows.

General Session; Wednesday afternoon, March 30: Dr. Donald G. Decker, Dean of the College, Colorado State College, Greeley.

General Session; Wednesday evening, March 30: Dr. Linus J. Pauling, Nobel Laureate, Professor of Biochemistry, California Institute of Technology, Pasadena.

General Session; Thursday, March 31: Dr. Robert H. Johnson, Superintendent, Jefferson County Public Schools, Colorado.

Business-Industry-Education Luncheon; Thursday, March 31: Dr. John Brattain, Nobel Laureate, Bell Telephone Laboratories, Murray Hill, New Jersey.

General Session; Thursday evening, March 31: Dr. John R. Heller, Director, U. S. National Cancer Institute, Bethesda, Maryland.

General Session; Friday morning, April 1: Dr. Leona M. Sundquist, Chairman, Department of Science, Western Washington College, Bellingham.

Elementary Science Luncheon; Friday, April 1: Dr. Joe Zafforoni, Professor of Science Education, University of Nebraska, Lincoln.

Banquet Session; Friday evening, April 1: Dr. George B. Kistiakowsky, Science Advisor to the President of the United States, The White House, Washington, D. C.

General Session; Saturday morning, April 2: Dr. John H. Fischer, Dean, Teachers College, Columbia University, New York City.

State Associations Luncheon; Saturday, April 2: Sponsored by the Missouri Science Teachers Association; Speaker to be announced at a later date.

• WORTH NOTING

A number of dormitory-style rooms accommodating four to six persons each will be available at the Hotel Phillips. Suites for four persons, usually, will be available at both headquarters hotels—the Muehlebach and the Phillips. Double rooms, with the possibility of an additional rollaway, should be plentiful, but single rooms may be scarce. *Plan now to share a room with others.* This will ease the housing problem and reduce the average cost per person. *Hotel reservation forms will be mailed to NSTA members in December.* Make reservations early.

Dr. Harold E. Tannenbaum is planning four workshops of three sessions each in four different areas of science. Two in each area will be for elementary teachers, one for elementary supervisors, and one for junior high school teachers. Attendance is limited to 20 persons in each workshop group; the fee is $3.00. Register early after forms reach you in December.

Groups desiring to arrange breakfasts or other special functions should write to the Executive Secretary at NSTA headquarters.

There are a few program spots still open in the "Here's How I Do It" sessions. Write the Executive Secretary if interested in making a 15-minute presentation.

The newly formed NSTA Section for Supervisors, Consultants, and Coordinators will hold specially planned sessions all day Tuesday, March 29, and Wednesday morning, March 30.

The Association for the Education of Teachers in Science will meet in conjunction with NSTA on Tuesday and Wednesday, and will co-sponsor the Friday morning session dealing with teacher education.

A feature of the Thursday evening general session will be the announcement of winners in the STAR '60 program. Top award of $1000 plus 55 others totaling $12,500 will be presented. (December 15 is closing date for submission of entries.)

• LOCAL COMMITTEES

More than 20 persons met all day on October 17 at the Phillips Hotel in Kansas City to lay out plans for all local arrangements for the convention. They were, mostly, those who will serve as chairmen of local committees. When all committee assignments have been filled, nearly 100 KC area teachers will be serving. Those to whom we are indebted for accepting major responsibility for providing vital services are as follows.

Coordinating and Advisory

Co-chairmen: Dr. H. Bailey Gardner, Public Information Service, Library Building, Ninth and Locust Streets, Kansas City, Mo.; Mr. D. H. Miner, Science Helping Teacher, 3949 Oak Street, Kansas City, Mo.

Registration

Chairman: Mr. Jay Danielsen, Vice-Principal, Central Junior High School, 3611 Linwood Boulevard, Kansas City, Mo.

Hospitality and Information

Chairman: Miss Rosemary Beymer, Director, Art Education, 1840 East Eighth Street, Kansas City, Mo.

Publicity and Promotion

Chairman: Dr. H. Bailey Gardner, Director, Public Information Service, Library Building, Kansas City, Mo.

Banquet, Dinner, and Luncheon

Chairman: Mrs. Frances Kerley, Supervisor, Homemaking, 1840 East Eighth Street, Kansas City, Mo.

Music and Entertainment

Chairman: Mr. Robert W. Milton, Director, Music Education, 1840 East Eighth Street, Kansas City, Mo.

Audio-Visual

Chairman: Mr. Donald W. Smith, Director, Audio-Visual Education, 1840 East Eighth Street, Kansas City, Mo.

Rooms and Facilities

Chairman: Mr. Robert E. Barr, Supervisor, Employee Personnel, Library Building, Kansas City, Mo.

Exhibits Committee

Chairman: Mr. T. Gardner Boyd, Director, Industrial Arts, 1840 East Eighth Street, Kansas City, Mo.

Children's Exhibits

Chairman (Grades K-6): Sister Anna Joseph, Redemptorist High School, 207 West Linwood Boulevard, Kansas City, Mo.

Chairman (Grades 7-12): Mr. D. H. Miner, Science Helping Teacher, 3949 Oak Street, Kansas City, Mo.

Demonstration Lessons

Chairman (Grades K-6): Miss Barbara Henderson, Director, Elementary Education, Library Building, Kansas City, Mo.

Chairman (Grades 7-12): Mr. D. H. Miner, Science Helping Teacher, 3949 Oak Street, Kansas City, Mo.

Tours

Chairman: Mr. W. S. Esther, Vice-Principal, Westport High School, 315 East 39th Street, Kansas City, Mo.

Production and Signs

Chairman: Miss Helen Janes, Director, Art Education, Library Building, Kansas City, Kans.

Another Student Award!

Winners of Science Achievement Awards for Students (SAAS) will receive one-year subscriptions to two science publications this year.

Science Digest will award one-year subscriptions to the 22 winners of national awards for projects that relate to metals or metallurgy.

Scholastic Magazines, Inc. has announced that all 220 regional and national winners will receive a free, one-year subscription to the publication *Science World*, which now includes *Tomorrow's Scientists* (the student publication formerly published by NSTA and now included in *Science World* in cooperation with NSTA). Many of the student reports entered in SAAS competition are selected later for publication in *Science World*. Teachers and students who have not already subscribed to this outstanding publication are urged to begin their subscriptions with the second semester. The subscription rate per semester is $1.00, which will provide eight issues during the balance of the school year 1959-60. Send subscriptions directly to *Science World*, 33 West 42nd Street, New York 36, New York.

Students entering SAAS competition should be encouraged to start their projects now. Reports must be mailed to regional chairmen not later than *March 15*. More information and entry forms are available from NSTA headquarters.

Teachers, *not students*, should write for the number of entry forms desired. (See Announcement, SAAS, September 1959 issue of *TST*, page 322.)

NSTA Activities

The following chart is presented as a working document based on the actions taken by the Board of Directors last July 1-3 (See also the September *TST* article by Dr. Donald G. Decker, "Beyond This Issue Toward Infinity").

Members of NSTA are invited to consider any and all elements contained in this chart and to communicate to the Board of Directors their reactions, ideas, or suggestions by writing to the Executive Secretary.

NSTA Organization, Program, and Budget, 1959-60

BOARD OF DIRECTORS

EXECUTIVE COMMITTEE

President

Executive Secretary

Treasurer | **Secretary**

President-elect | **Retiring President**

Regional Directors

I II III IV V VI VII VIII

COMMITTEE STRUCTURE

Standing Committee I: Science Education Activities for Youth	Standing Committee II: Professional Activities for Teachers	Standing Committee III: Association Activities for Members
1. Future Scientists of America Foundation Administrative Committee.	1. Convention Planning Committee.	1. American Association for the Advancement of Science Cooperative Committee.
2. *Science World* Advisory Board.	2. *Elementary School Science Bulletin* Advisory Committee.	2. American Association for the Advancement of Science Council.
	3. Evaluation of Business-Sponsored Teaching Aids.	3. Budget Committee.
	4. High School Chemistry Test Committee.	4. Committee on Business-Industry Relations.
	5. K-12 Committee.	5. Council for Research in Education.
	6. Legislative Committee.	6. Elections Committee.
	7. Magazine Advisory Board.	7. International Activities of NSTA.

Standing Committee I: Science Education Activities for Youth	Standing Committee II: Professional Activities for Teachers	Standing Committee III: Association Activities for Members
	8. NEA Safety Education Committee.	8. Membership Committee.
	9. Research Committee.	9. Policies Committee.
	10. STAR '60 (National & Advisory) Committees.	10. State Organization Committee.
	11. Teaching Materials Review Committee.	11. Publications Committee.
	12. Television Committee.	12. NEA Council on Instruction.
EDUCATIONAL AIMS		
The development, by each young person, of a habit of seeking the most reliable data to be used as a basis for discussion and in the determination of group and individual action.	Education and certification.	Promote professional growth.
The achievement, by all youth, of a clear understanding of the crucial dependence of the socio-economic life of the United States on the scientific and technical enterprise.	On-the-job competence.	Increase competence.
The development of effective personal adjustment consistent with current scientific knowledge of the physical and biological environment, as a means toward achieving confidence and security in the world today.	Status and recognition.	Engender enthusiasm for the profession.
The location and support of those young people who show promise of growing into productivity in the scientific endeavor.	Teaching conditions.	Engender pride in the profession.
ACCOMPLISHED BY		
The establishment of adequate science education opportunity for each child and youth at each grade level from kindergarten through twelve.	The establishment of an adequate science education supervisory staff in each state department of education.	A larger and more effective National Science Teachers Association.
	The assignment of a professionally prepared and competent person in every science teaching position.	Attendance at meetings, conferences, workshops, and conventions.
	A strong and effective state science teachers association in every state.	Contributing to *The Science Teacher* and other publications.
	Broader participation of state science education leaders in the formulation and execution of national association policies.	Serving on committees.
WITH THE RESULT OF		
Stimulating youth to engage in science activities.	Stimulating teachers and administrators.	Stimulating noneducational groups to support science education activities.
	Stimulating curriculum improvement.	Cooperation with other agencies for a balanced program for youth.
	Defining policies and programs that the Association accepts and promotes.	Stimulating program and policies of NSTA beyond the borders of continental U. S. A.

NOTE: Details of the NSTA budget will be reported at a later date.

▶ NSTA Debt Reduction

This is the second and certainly should be the final year of effort on the part of our members of NSTA to eliminate our remaining modest indebtedness to the National Education Association. This long-range loan from the NEA accumulated during the first several years of NSTA "Bootstraps" operations and reached at one time a total of $23,000. Last year in a drive spearheaded by Life Members of NSTA, contributions ranging from $1 or $2 to as much as $50 in some cases were received from nearly 3000 members of the Association. These contributions, plus a direct payment of $3000 by the Association, have reduced our obligation to about $10,000. The Association budgeted $5000 debt retirement this year, and all members are invited to contribute once more, if possible, or in some cases for the first time, in order that the final obligation to our parent Association might be completely eliminated. If one and all will pitch in and help, next spring we can burn the mortgage.

Actually the maximum indebtedness was accumulated over a period of about eight years and represented a deficiency of less than one per cent of the total budget. During this time membership dues varied from $2 to $4, but the value of membership services provided was in excess of $5.

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influenced by our emotions. It guides perception and is checked by perception. On the other hand, although all aspects of body and mind in a person are somehow related in a pattern of personality behavior, they do not all seem equally important in determining the characteristic Gestalt. They cannot all be developed and certainly not at the same time. Except when we encounter a Leonardo, we cannot avoid selecting and developing some powers at the cost of others. There simply is not enough time to develop all of our intellectual interests not to speak of all our practical aptitudes.

If the development of the powers of cooking, fishing, and roller skating get in the way of development of the powers of reading, writing, and problem solving, then the first must yield.

Let us look at the mind in action. What does it mean, educationally speaking, to develop the student's powers of thinking in the biological sciences? Anyone who sets out to teach his students to think in these fields is teaching them at the same time how to see, how to observe, how to use instruments, how to discipline impatience, how to curb the impulse to take short cuts. Is all this part of the mind? Trained observation in every field is an art. It is not merely looking, for it is guided by general ideas that structure the field of perception. Thinking about machines involves knowing how to make things. Thinking is not merely reasoning. Otherwise we would have to regard every paranoiac person as a thoughtful man. It is not accidental that thoughtful and sensible are closely related.

What does it mean to think about a play, or about a poem, or about people? It means also to feel, to imagine, to conjure up a vision. Why is it that we often say to some thoughtless person, "Put yourself in his place"? To another, "You haven't got the feel or the hang of it"? To a third, "You understand everything about the situation except what really matters"? We do not convey truths by this way of speaking, but we help others to find the truth. If artists and musicians think, their sensory discriminations must be relevant to the thinking they do. After all, we do speak of educated tastes. It is absurd, therefore, to say that the exclusive preoccupation of education should be the development of training of the mind.

Nonetheless, although the antithesis between these two points of view must be rejected, the accent has to fall on one rather than the other. To avoid the implicit faculty psychology associated with the term "mind" I prefer the term "intelligence." Intelligence suggests more than mere ratiocination. It suggests the ability to look for evidence and to discern the likely places where it can be found and the capacity to weigh it judiciously. The intelligent man knows when it is time to stop reasoning and to act; when it is time to stop experimenting and to declare his results. Of him one never says that he is educated beyond his capacities. He is wise rather than learned for he knows uses and limits of learning.

Content Versus Method

The second antithesis I wish to challenge is the one usually drawn between content and method in education. Shall one cover a great deal of ground or study in depth, stock the mind with useful information, or enable it to find the facts quickly? The danger of emphasizing content rather than method in education is that unless content appears live and meaningful to students it is transformed into a dull inventory of facts. To be live and meaningful, content must be related and connected to other content, to problems and issues, and wherever possible to live options. What better way is there of establishing

these connections and relations than to show the methods by which conclusions are reached? Where content is stressed at the cost of method, memory rather than understanding becomes the chief aid to educational progress. A good memory is a blessing, but the power of memory alone cannot put two memories together for new discovery.

The danger of stressing method over content is said to be equally great. It sacrifices content: the student is not required to know anything so long as he can talk suggestively about it or around it. This emphasis tends to regard any subject matter as the equal of any other for purposes of developing proper habits of thinking.

I confess that I do not see much danger to learning in giving the prime emphasis to method. By emphasis upon method, I mean upon critical method—upon criteria of evidence, norms of validity, rules of consistency, on "how we actually think" and "how we ought to think" in whatever field of study we want students to be informed about. This seems to me more important than stressing what we think because the how and the what, although distinguishable, are actually inseparable when we think soundly. When facts come into dispute or inferences are questioned, we find ourselves relying on rules or habits that control observation and the movements from statement to statement. In my experience, the most critical thinkers I have known have been the best informed. The citing of counter-instances is a phase of critical thinking. Nor does it follow that, because critical thinking should receive the greatest emphasis, any subject is as good educationally as any other for that purpose. To be sure, we can think critically about horse racing and show when it is wise to suspend judgment or hedge a bet or distrust a bookie. But it is possible to learn the same critical lessons by studying subject matter that has a wider range of generality.

The Democratic Viewpoint of Education

The phrase "democracy in education" has meant all sorts of bizarre things. To some people it apparently means that everything is settled by a majority vote by children in the classroom. I mean by the phrase simply this: the right of every child to equality of educational opportunity. Democracy in education is equality of opportunity to achieve through schooling an education commensurate with one's capacities. This is America's contribution to the history of education. It requires that we grant to our neighbor's children, no matter what their social status, the same rights to an education that we demand as parents for our own children. Anyone who accepts this principle seriously must acknowledge the great responsibility of the state as the public agency to equalize opportunities.

To say that all children have the same right to an education is not to say that all have the right to the same education. It does not mean that they have the right independently of their capacities to attend the same schools. It does mean some education for all. It leaves open how much and how long. It would be absurd if we confused "some education for all" with "the same education for all."

No matter how generous our hopes for mankind, to be reasonable they must be compatible with the facts of biological variation. Do the facts of biological variation defeat our ideal of democratic education, in the sense that it is futile to expect most students to profit by an education defined by the ends we have previously derived? If they do, then, as Jefferson foresaw, the prospects of our survival as a political democracy are extremely dubious. It seems to me, however, that it is quite reasonable to recognize the facts of biological variation in human capacities and still defend democracy in education. It requires that we distinguish between the function of schooling

The right of every child to equality of educational opportunity for the pursuit of his own capabilities. Terry Godwin 7 (Colesville Elementary School, Silver Spring, Maryland) is intent on uncovering the mysteries of a clock, while his sister Debra Godwin 4 finds greater enjoyment in the art of painting.

EARL GODWIN, NEA PHOTO

and the content of schooling, and strive to achieve the same function with different content, where content refers not to ends but to courses and methods and materials of study. These may be the same; they do not have to be.

It is not necessary to choose between the view that everyone should be educated in the same way and the view that liberal education is for a small elite while the rest of mankind are to be trained as hewers of wood and drawers of water for their intellectual betters. We can put this to a test by describing a hypothetical situation. Two highly gifted parents who have achieved academic distinction although they were brought up in underprivileged homes, confirm the Mendelian laws of heredity and rear a family of children whose native intelligence ranges from very dull to very bright. Let us assume that the parents themselves undertake to teach their children all of whom are equally dear to them. Would they not try to realize the same educational ends for all of them? Would they not want all their children to learn to speak and write clearly, to read and think effectively, to enjoy music and painting and the other arts of civilization, but each to the best of his ability and therefore in different measure? Where children's health is concerned, parents naturally provide special medical treatment for the weakest. Where intelligence is concerned they naturally provide special educational opportunities for the brightest. But they are equally concerned for the health and education of all of them. If they were not, they would be bad parents. A democratic society stands in the same relation to all the children of the community as good parents stand to their own children.

Nonetheless, equality of educational concern on the part of our hypothetical parents would not necessarily lead them to give the same instruction in all subjects to all their children even if in varying amounts. What a child cannot grasp about a foreign culture by mastery of its language he may learn by reading books on travel or anthropology. There is nothing undemocratic in diversifying the courses of instruction, the rate of instruction, and the methods of instruction.

The Appeal to Experience

This brings me to the necessity of an experimental approach. In one sense, an appraisal of any proposed educational end in terms of the consequences of pursuing it is experimental. Such an approach should not be regarded with hostility by those who stress "eternal and perennial values," because if the latter are not grandiose terms, concealing some parochial or partial interest, their validity will be established in the here and now of experience.

Even if an educator claimed that his educational aims were authenticated by an infallible insight, surely he could not reasonably claim to know the methods and means by which they could best be realized. The intellectual scandal of much recent discussion between traditionalists and some progressive educators is the attempt by both sides, but especially by the former, to settle questions in this area not by inquiry or experiment but by dogma.

The phrase "progressive education" is today very much at a discount—and deservedly so—because of the number of educators who thought they could remain progressive while ceasing to be liberal. Originally, however, all it meant was an acceptance of the principle of democratic education and a reliance upon the findings of scientific psychology about the learning process. These two positions were revolutionary at the time they were formulated, and they still constitute the law and the prophets for modern educators, everything else being commentary. Some progressive educators have deduced what procedure should be followed in educating the young rather than following the lead of experimental evidence. But some of their critics, who have counted only the failures of progressive methods and not their successes, have been even more dogmatic and undiscriminating in their claims, holding them responsible for educational phenomena and conditions that must be laid at the door of society. There are critics who tell us that the schools have failed to teach their charges, and failed most miserably with the gifted, and in the same breath concede that their college students as a whole are more serious, abler, more excited by ideas than their precursors in the golden age that existed before the days of progressive education.

There is a great deal of what is called "experimentation" always going on in American education, but most of it is not experimental, since it is conducted without proper controls. The result is that we think we know more than we actually do about the best courses to teach and the best ways of teaching them. The fact that something is new does not make it experimental. Nor does the desirability of experimentation mean that we must keep on experimenting about the same things. By this time we already should know what are the best methods of teaching children to read,

of teaching chemistry in high schools, of teaching economics in colleges.

Our very metaphors sometimes betray that we are taking for granted what might very well be in dispute. One of our leading traditionalists, Mortimer Adler, has written: "Human differences in capacity for education can be thought of in terms of containers of different sizes. Obviously a half-pint jar cannot hold as much liquid as a quart or gallon jar. Now the poorly endowed child is like the half-pint jar, and the gifted child like the quart or gallon container." He concludes not only that each container must be filled up to the brim but that each must be filled with the same rich, thick "cream of liberal education."

The comparing of children to different measures, coupled with the conception of teaching as the pouring of the same stuff into passive containers, expresses a point of view which is hard to reconcile with what we know about children as organic creatures and learners whose differential responses determine how much they can assimilate. Even cream cannot be poured into children with safety, no matter how ingenious our funnels. It would help to change our metaphors. Our experimental task is to find and offer the appropriate curricular nourishment for different types of organisms that will enable them to achieve the full measure of their growth and health. That curricular nourishment may be the same or different. The test is the function it performs in the life of the child. The same function will not give us the same result. A dull child will never be able to read as well or as intelligently as a bright child, and an ordinary child will never be able to play as well as a musically gifted child. But both children can be so educated that each enjoys reading and music. Both can acquire something of the grace and taste associated with the liberal arts. They may not both be able to do so by studying the same subjects.

Vocational Education

Approximately one-quarter of all our students are incapable of completing the requirements of a good academic high school and going on to a liberal arts college. By increasing the number of schools and teachers, decreasing the size of classes, and improving skills of instruction, we can do something to bring down this number. Even so, the evidence shows that there will always be a large group unable to profit by the traditional and conventional courses of study. What shall we do with them?

It seems only common sense to say that the education of this fourth of the nation should not be so organized as to interfere with or dilute the education of the other three quarters. Conversely, the education of the latter should not be a ground to deprive the former of their educational rights. The problems here are admittedly difficult. We should keep these students in school as long as they can profit significantly by instruction. We should put them in special classes if they can learn better that way. We should instruct them in the skills and subjects that will enable them to begin their vocational experience at an earlier age than their more gifted brothers and sisters—who, sooner, or later, must prepare themselves to earn a living too.

This introduces the complex problem of vocational education, which is often bedeviled by the assumption that where it begins, liberal education must end. Yet we do not make the same assumption about professional education, which is distinguished from vocational education not only because it requires better brains but because it enjoys a higher social status and more money. Until the necessity for earning a living disappears, there can be no reasonable objection to using the schools to prepare people for a good living as well as for a good life.

Book Reviews

Education in the Age of Science. Brand Blanshard, Editor. 302p. $4.50. Basic Books, Inc., 59 Fourth Ave., New York 3, N. Y. 1959.

One of the better books, in my opinion, to be read by all who are concerned with the burning problems of our educational systems and institutions today. It is better in the sense that it presents essays on education by 14 distinguished scholars and leaders in philosophy, science, and science teaching spread over a wide spectrum of viewpoints. Eight of the papers were presented in paired juxtaposition in a seminar sponsored by the Tamiment (Pennsylvania) Institute in June 1958. They were then discussed by panels, and much of the discussion is included in transcript form. All of this provides stimulating reading and encourages critical thinking about our schools and their curricula, no matter what disposition toward a particular philosophy of education and the means of its implementation the reader may have. The stature of the 30 contributors to this book compels considered attention to their arguments. These men and women, in their views on education, range from Ernest Nagel, John Dewey Professor of Philosophy, Columbia University, and Sidney Hook, Professor of Philosophy, New York University, to Arthur Bestor, Professor of History, University of Illinois, and Douglas Bush, Gurney Professor of Literature, Harvard University. Of the alternatives open to the editor, nothing could have pleased this reviewer more than the choice of Sidney Hook's essay to open the book and the classic essay of Alfred North Whitehead, "The Aims of Education," as the closing piece. The one direct representative of science teaching, Fletcher G. Watson of Harvard University, makes the most of the pages allocated to him in the total volume.

Robert H. Carleton
Executive Secretary, NSTA

The Challenge of Science Education. Joseph S. Roucek, Editor. 491p. $10. Philosophical Library, 15 East 40th St., New York 16, N. Y. 1959.

It may be inevitable that a compendium of articles prepared by thirty-two writers and augmented by a report of a committee and a report of a conference, would include some presentations of considerable strength and others of doubtful value. The work was apparently stimulated by an event in October of 1957. It is announced as an "effort to synthesize the cross-currents of thinking and the evaluation of education practices in the field of science . . ." and to identify the possibilities of improving science education in the face of international need.

The thesis is presented in a rambling "Case For and Against Science and Scientism." As a consequence the articles that follow relate only moderately well and episodically to the thesis. One wishes that more space had been given to science education in relation to the national welfare, history, and religion.

The wisdom concealed in the article on science in elementary education does not pass unnoticed. Thoughtful explorations in the articles on physics and on biology give body to the idea that science is for the life of everyone. A review of the activities of federal and state governments provides concisely much useful information for him who wishes to identify the challenge and meet it. Such articles and later ones on adult education, learned societies, and the four found in the section on Comparative Aspects have merit, but separately. They illuminate science education as a function of society. The synthesis of ideas presented throughout remains a discouraging challenge to the reader.

John S. Richardson
Professor of Education
The Ohio State University
Columbus, Ohio

The Life of Sir Alexander Fleming. Andre Maurois. 293p. $5. E. P. Dutton and Company, 300 Fourth Ave., New York 10, N. Y. 1959.

This life of a scientific genius is by a man who is himself a genius at writing biographies. In order to write the story of the discoverer of penicillin, Andre Maurois prevailed upon a scientist friend to recapitulate Sir Alexander's experiments leading to the development of the drug. Thus he was able to picture the imagination, drudgery, and determination required in the pursuit of a major scientific project.

The book follows him from his boyhood years in Ayrshire, Scotland, to London where he read for his medical examinations, according to the custom of the day, under Sir Almroth Wright, and developed an interest in the nature and cure of infections.

It follows him through his years of teamwork with Florey and Chain at St. Mary's Hospital in Paddington, London, to Sweden where the three received the Nobel Prize in recognition of their production of a lifesaving drug from the mold, *Penicillium notatum.*

Margaret J. McKibben
Assistant Executive Secretary, NSTA

VISITING ASSOCIATESHIP IN EDUCATION

The Test Development Division of Educational Testing Service is offering a Visiting Associateship in Education for the summer of 1960. The basic stipend is $800, plus transportation costs and allotments for dependents. Completed applications must be submitted by February 29, 1960. Applications may be obtained from Mrs. W. Stanley Brown, Test Development Division, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee
Dr. Robert A. Bullington, Chairman
Northern Illinois University, Dekalb

BOOK BRIEFS

THE PRACTICAL DICTIONARY OF ELECTRICITY AND ELECTRONICS. R. L. Oldfield. 216p. $5.95. American Technical Society, 848 East 58th St., Chicago 37, Ill. 1959.

Contains a large collection of technical terms collected from trade journals, supplier's catalogs, and company manuals. Also has a handbook section which includes formulas, tables, and illustrations. Handy reference for those interested in electricity and electronics.

DIAMONDS. Herbert Zim. 64p. $2.50. William Morrow and Company, Inc., 425 Fourth Ave., New York 16, N. Y. 1959.

A factual book with graphic illustrations. Tells the story of the origin, distribution, nature, and uses of the diamonds of the world. Written for the middle elementary levels in a simple style that has not sacrificed truth.

THE SIMPLICITY OF SCIENCE. Stanley D. Beck. 204p. $3.75. Doubleday and Company, Inc., 575 Madison Ave., New York 22, N. Y. 1959.

Although written for the non-scientist, the book is so engagingly written that the chemist, physicist, and biologist will enjoy the situations and ideas.

Spontaneous generation and the evolutionary concept provide the arena for the unfolding of the development of theory and academic controversy.

Formal logic, chance, probability, and the uncertainty principle are presented in a particularly lucid framework of examples.

This book is well suited to give the layman and young science student an appreciation of the aims and workings of science.

YOUR MICROSCOPE AND HOW TO USE IT. Hy Ruchlis. 32p. 70¢. Science Materials Center, 59 Fourth Ave., New York 3, N. Y. 1959.

Detailed description of the microscope and how to use it, written for the beginner but of value to anyone. Includes slide preparation and experiments and projects with the microscope. Well illustrated with clear-cut drawings and photomicrographs.

PLANET EARTH. Karl Stumpff. 191p. $5. The University of Michigan Press, Ann Arbor, Mich. 1959.

Written in a scholarly fashion, this book is filled with factual material recently discovered in the fields of geophysics and astronomy. It portrays the physical nature of the earth from atmosphere to core and locates the earth in respect to other astronomical bodies. It is rare for an author to report in unified fashion two specialized fields without loss of authenticity. Excellent for the general reader interested in the earth.

RAYS—VISIBLE AND INVISIBLE. Fred Reinfeld. 204p. $3.50. Sterling Publishing Co., Inc., 416 Fourth Ave., New York 16, N. Y. 1958.

A general discussion of most phenomena involving rays and waves. Solar energy and its uses presented in a very attractive manner. Various devices based on infrared and ultraviolet radiations, the techniques of radio, television and radar, and their role in the technological advance, are well described in a non-technical manner. Contains a simple description of atomic energy, atomic radiation, and atomic bombs. Recommended for those who are not associated with physics but who want to keep informed of its developments and applications.

THE STRANGEST THINGS IN THE WORLD. Thomas R. Henry. 200p. $3.50. Public Affairs Press, 419 New Jersey Ave., S.E., Washington 3, D. C. 1958.

Consists of short, well-written essays about unusual and fascinating living things from all parts of the earth. Based in large part on material from the Smithsonian Institution. Interesting pick-up reading for high school students and adults.

HOT AND COLD. Irving Adler. 128p. $3. John Day Company, Inc., 210 Madison Ave., New York 16, N. Y. 1959.

An excellent coverage of high and low temperatures. Discusses the theories of heat, its measurement, and methods of transfer. Includes application of heat in furnaces, photography, and solar furnaces. Gives information on cooling including description of substances cooled to near absolute zero. For junior-senior high students. Illustrated.

ROCKET SCIENCE FOR AMATEURS. L. E. Lewis, Jr. 50p. $2. Sooner Science Publications, P.O. Box 145, Norman, Okla. 1958.

Written for science teachers and amateur rocketeers. Information includes the physics and chemistry of rocketry, rocket components and their design, and plans and specifications for zinc-sulfur rockets. Emphasizes safety in rocket construction and launching. Illustrated with drawings, graphs, and photographs.

1001 QUESTIONS ANSWERED ABOUT THE NEW SCIENCE. David O. Woodbury. 358p. $6. Dodd, Mead & Company, Inc., 601 West 26th St., New York 1, N. Y. 1959.

Basic concepts and principles of the New Science are presented in the form of questions and answers. The New Science includes such areas of our culture as space, atomic energy, engineering, physics, electronics, chemistry, biology, petrology, and mathematics. Both the questions and answers are direct, simple, and understandable to the average citizen. They are sufficiently informative to assist the technically trained science student. Should be a desirable addition to either a private or public library.

WHAT'S GOING ON IN SPACE. David C. Holmes. 256p. $3.95. Funk & Wagnalls Company, 153 East 24th St., New York 10, N. Y. 1958.

This book of Commander Holmes, U.S.N., is a review of events and experiments in space travel since July 29, 1955. The book is somewhat philosophical in its approaches toward the reasons for the growth and development of space programs in the United States. Only two chapters are specific in nature; these deal with the Explorer and Vanguard programs.

TEACHING UNIT IN ASTRONOMY. J. Russell Smith. 149p. $2.75. Vantage Press, Inc., 120 W. 31 St., New York 1, N. Y. 1959.

This book offers the elementary and junior high school teacher much that he needs to know to organize and develop desirable units of study and projects in astronomy. Contains illustrative materials, subject-matter sources, and a glossary of terms. The study units are arranged for effective adaptation at various grade levels from 1 through 9.

ENGINES, ATOMS, AND POWER. Amabel Williams-Ellis. 64p. $2. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1958.

Covers the development of the engine as a source of power. Includes excerpts on the contributions of Benjamin Franklin, John Dalton, and James Watt. Ends with the development of nuclear power. Good for junior high school students. Authoritative and well written.

ROCKETS AROUND THE WORLD. Eric Bergaust. 48p. $2. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1958.

An illustrated book giving specifications on the rockets developed in various countries. Evaluates the missile programs of various countries and gives a brief history of the rocket principle. Interestingly written, using up-to-date facts. Suitable reference for everyone interested in the space age. Contains a glossary.

FUNDAMENTALS OF RADIO TELEMETRY. Marvin Tepper. 116p. $2.95. John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. 1959.

In non-mathematical terms, describes applications of telemetry to research and development. Discusses briefly the binary number system. Assumes a basic knowledge of electronics. Examples from applications to missiles.

BUILDING THE AMATEUR RADIO STATION. Julius Berens. 128p. $2.95. John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. 1959.

Volume Two of Rider's *Ham Radio* Series. Written for those who have novice or general-class license. Discusses tools, components, and procedures for building transmitter and receiver. Lists commercially available ham equipment, and suggestions for operation of amateur station.

THEY WANTED THE REAL ANSWERS. Amabel Williams-Ellis. 64p. $2. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1958.

Relates the investigations of Aristotle, Pasteur, Darwin, and Edison in an interesting fashion for the young reader. A quality evident in this book is the manner in which scientific questioning and method are made important. Very suitable for ages 8-12.

HUMAN TYPES. Raymond Firth. 176p. 50¢. A Mentor Book. The New American Library, 501 Madison Ave., New York 22, N. Y. 1958.

In this book the author examines a wide range of primitive societies. He emphasizes the importance of culture as the factor which governs the actions of man. This book has far-reaching implications for contemporary society.

MAINSPRINGS OF CIVILIZATION. Ellsworth Huntington. 669p. 75¢. New American Library of World Literature, Inc., 501 Madison Ave., New York 22, N. Y. 1959.

A Mentor reprint of a 1945 classic. A careful and detailed exposition of the view that human institutions, societies, and history are shaped by heredity, geography, and climate in such a way that there is hope of understanding at least the major patterns of human affairs. A book that should be known by every thoughtful biologist, social scientist, and politician.

NSTA Teaching Materials Review Committee

Reveiws and reports on teaching materials used in elementary and secondary school science programs will be continued in this series. NSTA and Northern Illinois University are cooperating in this joint project and the committee will be chaired by Dr. Robert A. Bullington. Suppliers and publishers are requested to send duplicate copies directly to Dr. Bullington of any teaching materials or books sent to NSTA.

The full roster of committee members will appear in a later issue of TST.

PROFESSIONAL READING

"The Science Teaching Improvement Program of the American Association for the Advancement of Science: An Evaluation." By John W. Gusted. *Science Education,* 43:89. March 1959. The STIP program involved a study of the effects of science counselors working with science teachers in four states. Data were collected through questionnaires completed by science leaders, principals, and others involved in the program. The help provided appeared to be needed, well received, and of value.

"The Science Manpower Project." By Frederick L. Fitzpatrick. *Science Education,* 43:121. March 1959. The status report of a project was designed to effect improvement in (1) school science programs and (2) teacher-training programs.

"The Indianapolis Science Story." By Newton G. Sprague. *School Science and Mathematics,* 59:373. May 1959. How a science program was developed and implemented.

"Domestication of Food Plants in the Old World." By Hans Helbaek. *Science,* 130:365. August 14, 1959. The origins of the wild prototypes of our present-day barleys, wheats, chick peas, grapes, olives, dates, and other food plants are traced. Investigations include archeological, paleobotanical, and genetic methods.

"Science Begins at Home." By Anne Roe. Thomas Alva Edison Foundation, Inc. 1959. A pamphlet prepared from an original address to Edison Foundation Institutes based on research by Dr. Roe, past president of the Clinical Division of the American Psychological Association. It deals with family background of the scientist and the child-rearing pattern involved. Single copies are free on request to the Foundation.

AUDIO-VISUAL AIDS

PARTNERSHIPS AMONG PLANTS AND ANIMALS. The concept of interdependence among living things is illustrated on a level suitable for intermediate and junior high grades. Examples include plant-plant, plant-animal, and animal-animal relationships. Excellent photography and accurate narration. 11 min. Color $110, B&W $60. 1959. Coronet Films, Coronet Building, Chicago 1, Ill.

THE LAWS OF GASES. Gives introduction to laws of gases, covering Boyle, Charles, Avagadro, and Dalton. Laws stated and demonstrated by reference to machines and animation. Formula and derivations given. Relationships shown between pressure, volume and temperature of confined gas, law of partial pressures, and molecular weight of gas. Recommended for junior and senior high school. 11 min. Color $110, B&W $60. 1958. Coronet Films, Coronet Building, Chicago 1, Ill.

THE COLLOIDAL STATE. Defines and distinguishes colloids, shows methods of preparation, and explains uses in modern chemistry. Excellent aid to classroom presentation of the subject in high school and college chemistry. 16 min. Color $165, B&W $90. 1959. Coronet Films, Coronet Building, Chicago 1, Ill. (See next page.)

SCIENCE OF THE SEA. An excellent film designed to show the influence of the sea on the earth's weather and climate, the nature of the sea floor, the types of flora and fauna, and their food relationships. Illustrates how scientists acquire information concerning the ocean and its floor. A stimulating exposition of the study possibilities in this relatively new science. For high school or college. Produced for the Wood's Hole Oceanographic Institute. 19 min. Color $195. 1956. International Film Bureau, Inc., 57 East Jackson Blvd., Chicago 4, Ill.

THE MOON AND HOW IT AFFECTS US. Basic facts about the moon and its relationship to the earth are effectively presented. Tides, eclipses, and moon phases are explained. Launching of a satellite is shown. For grades 4-6, but of value in junior high grades. 11 min. Color $110, B&W $60. 1958. Coronet Films, Coronet Building, Chicago 1, Ill.

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor as early as possible.

November 7-10, 1959: NSTA Conference on Selected Problems in Secondary School Science, Burlington Hotel, Washington, D. C.

November 8-14, 1959: American Education Week. Theme: Praise and Appraise Your Schools

November 26-28, 1959: 59th Convention, Central Association of Science and Mathematics Teachers, Chicago, Illinois

November 27-29, 1959: Regional Conference, Statler Hilton Hotel, New York City

December 26-31, 1959: NSTA Annual Winter Meeting with science teaching societies affiliated with the American Association for the Advancement of Science, Hotel Sherman, Chicago, Illinois

January 28-30, 1960: 29th Annual Meeting, American Association of Physics Teachers, Hotel New Yorker, New York City

February 10-13, 1960: 33rd Annual Meeting, National Association for Research in Science Teaching, Chicago, Illinois

March 29-April 2, 1960: NSTA Eighth National Convention, Muehlebach and Phillips Hotels, Kansas City, Missouri

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